EFFECTS OF PLANT POPULATION AND RATE AND PLACEMENT OF FERTILIZER ON YIELD AND NUTRIENT UPTAKE OF CORN ON LEON FINE SAND

By

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INTRODUCTION

There are numerous factors which affect crop production. Emphasis has been placed on controllable variables in developing a relationship between crop yields and multiple factors of production.

Experiments have been conducted throughout the world on growth and nutrition of corn and contrasting results have been obtained due to variations in season and location. In recent years, there has been a great deal of interest in determining the maximum potential production of corn. Lamar Ratliff (104) reported a yield of 304 bushels of corn per acre in Mississippi. Yields of 200 bushels or more have been reported from other parts of the United States. However, most attempts to produce 200 bushels of corn per acre have failed. This may be due to the inability of adapted prolific hybrids to produce two or more ears on all plants under light conditions found at high population densities. In Florida, maximum corn yields have been increasing for several years. In 12 years the increase in the maximum yield has been over 200 per cent; however, the average yield per acre was only 38 bushels per acre in 1963.[1]

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[1] Florida Department of Agriculture, Agricultural Statistics, Florida Department of Agriculture. Tallahassee, Florida, 1963.

The factors limiting maximum crop production in Florida have not been clearly determined (14, 32, 47, 100, 115). Rainfall distribution, soil fertility, diseases and insects, and yielding ability of hybrids are listed as limiting factors to corn production, but other factors such as light, carbon dioxide and temperature have received little attention as possible limiting factors (115).

Another problem which has received considerable attention in Florida in recent years is lack of suitable soils for crop production. Interests have been focused on the use of flatwood soils for growing crops due to high land prices along with the expansion of the livestock industry (126). However, these flatwood soils have not been used extensively for crop production due to the presence of a fluctuating water table and other management difficulties. Liming, fertilization with major and minor elements, and control of the fluctuating supply of water are recognized management problems (25, 34, 36, 67, 114). However, the influence of minor elements and water table has not been thoroughly investigated.

The present study was started to determine how corn yields, nutrient uptake, and recovery of fertilizer nutrients are affected by fertilization rates and placement patterns, plant population and hybrid on flatwood soils.

REVIEW OF LITERATURE

Effects of Fertilization on Growth and Nutrition of Corn

Proper fertilization for maximum corn grain production with maximum efficiency has become a subject of considerable concern. Large numbers of experiments have been carried out concerning time, method, type and rate of fertilizer application in various parts of the world. Attempts have been made to find factors involved in promoting growth and increasing corn yields and considerable progress has been made in some areas.

Through adequate fertilization and adoption of proper soil management practices, yields of corn of 100 bushels, or more, per acre can be produced on soils once considered unsuited to this crop. It is now known that unprofitable yields of corn on many soils are due mainly to the failure of soils to supply sufficient nutrients to the plant.

(Smith (129) recommended rates of 160 to 215 pounds of N, 45 to 80 pounds of P_2O_5, and 90 to 175 pounds of K_2O per acre for production of 100 bushels of corn (including stover) per acre in Missouri. In Tennessee, Long (76) found that 160, 55, and 100 pounds of N, P_2O_5, and K_2O per acre, respectively, were needed.) Because of the high nutrient requirements of maize research workers have concluded it to be a good indicator of the nutrient status of soil and of the effectiveness of fertilizer added to the soil.

Earlier works by Jones and Houston (61) and more recently by Sayre (119) indicated that the period in which the plant exercised the greatest demand for the nutrients began about 10 days before tasseling and ended about 25 to 30 days later. Sayre (119) found a maximum rate of N absorption of more than 4 pounds per acre per day during the tasseling and silking stage. Chandler (11), in North Carolina, studied the nutrient uptake of corn grown under a high rate of fertilization. He observed that although corn absorbed large amounts of available nitrogen throughout the season, the most rapid nitrogen uptake occurred during the period of early plant growth and the period of grain production. There was a continuous phosphorus uptake to within 2 to 3 weeks of maturity. Corn grain contained 70, 82, and 16.5 per cent of the total plant uptake of nitrogen, phosphorus, and potassium, respectively. It is logical to assume that it is very important to supply the plants with ample quantities of nutrients, especially nitrogen and particularly during the period from about 10 days before tasseling until 25 to 30 days after tasseling.

Many investigators (8, 20, 31, 50, 68, 69, 103, 105, 140) found a marked increase in corn grain yields with nitrogen application. Jenny (56) observed a definite parallelism between the nitrogen content of soil and yields of corn. He found that with 12 different Missouri soils under similar environments, average corn yields on unfertilized plots were closely related to soil nitrogen content. Further evidence of a direct relationship between soil nitrogen content and corn yields was shown by Salter (117).

Harshbarger _et al_. (44) found that use of 200 pounds of 8-8-8 fertilizer before planting and 200 pounds of ammonium sulfate as side-dressing increased the grain fraction of corn by 13 per cent. Ratliff (104) showed that with good cultivation, productive hybrids and adequate water supply, corn could make use of considerably heavier dressings of fertilizers than is usually suggested. He was able to obtain 304.37 bushels per acre by an application of 1000 pounds of 14-14-14 fertilizer and 300 pounds NH_4NO_3.

Results of an experiment by Pumphrey and Harris (103) indicated that the efficiency of nitrogen use was decreased as nitrogen rates were increased from 40 to 120 pounds per acre and was greater on low production soil than on a medium production soil at all levels of nitrogen.

The percentage recovery of nitrogen decreases as the rate of nitrogen application increases (50, 69). Krantz and Chandler (69) were able to obtain 68, 54, and 50 per cent nitrogen recovery from nitrogen application rates of 110, 160, and 180 pounds per acre, respectively. Ohlrogge *et al*. (92) recovered, in general, 45 to 50 per cent of the applied nitrogen in the grain and stover of corn. However, as much as 60 per cent of the side-dressed nitrogen was recovered under ideal conditions. Viets and Domingo (141) obtained 48 per cent nitrogen recovery in the grain of corn on loamy sand.

On phosphorus deficient soils, large amounts of phosphorus fertilization are needed. However, on soils with high phosphorus fixing capacity, the major phosphorus applications are made earlier in the rotation. Krantz and Chandler (69) obtained yield increases ranging from zero to 35 bushels per acre with phosphorus fertilization, depending on the phosphorus content of the soil.

Potassium fertilizers are needed for maximum crop production. The work done by Reid and York (106) involved two successive crops of ground nuts, soybean, cotton, and maize grown on a limited volume of soil. The second crop of corn, in the series containing nitrogen and phosphorus but no potassium, yielded only 20 per cent of the series supplied with all three major plant nutrients. Forsee *et al*. (33) was able to increase corn yields from 26 bushels per acre to 63 bushels per acre by applying potash.

When an application of fertilizer increases the amounts of plant material, there is usually a corresponding increase in total nutrient uptake. Chemical soil tests, plant analysis, or a combination of these two are often used in diagnosing nutrient requirements of plants. Numerous workers (1, 4, 68, 138, 142) have shown that addition of nitrogen to soil increased the nitrogen percentage in the leaves and grain of corn. Fulton and Findlay (35) found a higher coefficient of correlation between grain yield and nitrogen percentage in the topmost leaf than between grain yield and nitrogen percentage in the grain. Results of experiments by Viets _et al_. (142) showed that the nitrogen content of leaves selected before silking gave lower correlation with yields than those selected at silking. The correlation between yield and nitrogen content at silking was high if plants at this stage had accumulated about 60 per cent of the total seasonal uptake of nitrogen.

Numerous workers (4, 35, 138, 142) have reported an increase in the per cent of nitrogen in corn leaf and grain tissue with the application of fertilizer nitrogen. However, there was some disagreement as to the nature of the relation between applied nitrogen, nitrogen content, and yield.

In conclusion, large yields of corn are dependent upon a plentiful supply of plant nutrients in proper combination with other growth factors. Adverse seasonal conditions and poor physical, chemical, and biological properties of soil are among major factors which reduce the effectiveness of fertilization. In order to produce good yields of corn, proper rates and types of fertilizers in combination with best hybrids and varities on suitable soils under favorable climatic conditions are required.

Fertilizer Placement

Placement of fertilizer is important to effective use of nutrients by plants. Incorrect placement of fertilizer may result in crop losses through damage to the germinating seeds or young seedling. Plant root distribution with time and fixation of fertilizer nutrients by the soil are additional factors which may be considered in the placement of fertilizers.

When fertilizer is applied to the soil it is subject to physical, chemical, and biological phenomena. Miller and Ohlrogge (86) stated,

> The addition of a single salt or salt mixture at a point in the soil is followed by a series of interrelated physical, chemical, and biological phenomena. Literally all physical matter within and immediately adjoining the fertilized zone is directly or indirectly affected by, or contributes to, the dynamic equilibrium. Basic laws of soil and fertilizer chemistry and physics and plant and animal biology interrelate to contribute to the final efficiency of nutrient uptake.

A good deal of work has been done on fertilizer placement, and many claims and counter claims on the superiority of one type of fertilizer placement over another have been made. It should be pointed out that no type of fertilizer placement is the best for all situations. One type of fertilizer placement may prove to be superior under one set of conditions while elsewhere it may be practically undesirable. Bear (3) indicated that the four variables involved in efficient fertilizer use were the kind of plant, the nature of the soil the type of fertilizer salt, and climatic conditions. The importance of the nature of the soil and the type of fertilizer is shown by the work of Speer et al. (130) who found that banding of several phosphorus compounds on Susquehanna sandy loam enhanced their availabilities, whereas, little effect was secured by banding dicalcium phosphate. Banding on Houston black clay did not accelerate the availability of any fertilizer used.

The problem of improper fertilizer placement is not a new one. However, new interest has been focused on this problem due to the more general use by the farmers of higher rates of higher analysis fertilizers applied at planting. Many workers believed that the major cause of limited fertilizer response is improper placement. Cummings (19) stated that "the most efficient and most effective placement of fertilizer is that which provides an adequate supply of soluble nutrients in a well aerated zone of moist soil occupied by actively absorbing plant roots at the period of growth when the demand of plant for nutrients is most acute."

A large proportion of mixed fertilizer used in the United States is applied in localized zones in the soils. The majority of this banded fertilizer is applied at planting. Miller and Ohlrogge (86) stated that "a plant-available or potentially-available form of added nutrient must be placed in the soil where it will intercept the extending root system when added as immobile nutrients. Mobile forms and immobile forms which become movable may be relocated from the point of placement into absorption areas subsequent to application. The nutrients must occupy sufficient space not only for interception, but also to permit the preferential development of actively absorbing root surfaces within the fertilizer zone. During proliferation and nutrient uptake the other requisites (temperature, aeration, water, etc.) for uptake must be favorable."

A knowledge of the movement of salts in soil is helpful in understanding the fundamentals of fertilizer placement. Among fertilizer materials, nitrates move freely in the soil, while potassium and ammonium salts move somewhat slower and phosphate very little. Sayre and Clark (118) concluded from a greenhouse study that soluble nitrogen and potassium were major causes of damage to the germinating seeds or young plants from improper fertilizer application. Injury to seeds and seedlings by fertilizer salts appears to be due primarily to the osmotic effect (10, 15, 127). Lawton (71, 72) suggested the use of slowly soluble and/or insoluble materials to coat fertilizer particles to reduce their solubilities. Apparently plants which are able to tolerate high salt concentration without marked injury have an adaptative mechanism. This area needs further study.

Placing of comparatively small amounts of fertilizer in bands near seed has received considerable attention. The further the fertilizer band is placed from the seed, the lower is the probability of root interception. The number of roots which intercept the band is inversely proportional to the distance the band is placed from the seed.

Experiments involving fertilizer placement with maize by Millar et al. (84), Nelson et al. (90), Pesek and Dumenil (97), Prummel (101), and Terman et al. (135) and those with other crops by Cooke (17, 18), Duley (26), Enyi (30), Lewis (74), Lewis and Strickland (75), Prummel (102), Reith (107), Smith (128), and Welch et al. (146), showed in general better response with band placement of fertilizer or drilling with seed than broadcasting. In 1948 the National Joint Committee on Fertilizer Application stated that high rates of fertilizer for corn should be drilled at 2 inches to one side and 2 inches below the seed level. Somewhat similar dimensions were recommended for small grains by Robertson et al. (111). Millar et al. (83, 84) observed that fertilizer placed in a band to one side of the seed was as effective as fertilizer placed in bands on both sides of the seed. Yields of corn were not affected markedly whether the fertilizer was plowed under or side placed in bands below seed (83).

In the work cited above, broadcast and localized application did not have the same concentration of fertilizer per unit volume of fertilized soil; DeWit (24) introduced a theory by which one can estimate a nutrient uptake from localized placement from the uptake obtained with broadcast application of fertilizer. His theory is based on the assumption that the concentration of fertilizer per unit volume of fertilized soil is the same for both placement patterns, even though the proportion of the total soil occupied by fertilizer is smaller with localized placement than with broadcast application.

The calculated relationship between uptake of nutrient from localized and broadcast application was called "compensation function" by DeWit, because as the proportion of soil occupied by fertilizer decreased, there was an increased nutrient uptake by plants per unit volume of fertilized soil. The compensation function is represented by the equation

$$\frac{U_r}{U_b} = \left(\frac{X_r}{X_b}\right)^{0.44}$$

where U_r and U_b are total nutrient uptake from the fertilizer with localized and broadcast application and X_r and X_b are width of fertilizer band and the distance between crop row, respectively.

Studies with radiophosphorus conducted during recent years have shown that the plant will derive more phosphorus from banding than from broadcast application (5, 90, 130, 146). Nelson *et al.* (90) observed that fertilizer mixed in the row or placed with the seed increased uptake of applied phosphorus by corn during early growth to a greater extent than when placed in bands separated from seed. However, as the season progressed, these differences disappeared. Similar results were obtained by Duley (26), Robertson _et al_. (112), and Weidemann and Millar (145). Millar and Ohlrogge (86) found that when nitrogen was mixed with the phosphorus band, a 100 per cent increase in weight of phosphorus per plant was obtained at all soil levels of phosphate. However, when the nitrogen and phosphorus bands were separated, the increases in uptake of phosphorus due to the nitrogen were 50 and 25 to 30 per cent at low and high soil phosphate levels, respectively. Several factors affecting the phenomena have been suggested: nitrogen salts (54), residual acidity (150), anion-cation ratio in the plant (79), root proliferation (86), cation exchange capacity of root (80), and root efficiency (39). Results obtained by Stanford and Nelson (132) indicated a greater utilization of applied phosphorus by the plants when fertilizer was placed at the seed depth in the band in one or both sides of the seed than placing in a single band above or 3 inches below seed level. Cooke (17, 18) found placing fertilizer near the seed resulted in higher yields of peas and beans, whereas, crops such as sugar beet and kale made better early growth with placing fertilizer beside the seed than with broadcast. However, the two methods of application gave similar results at harvest for later crops.

The ability of plants to absorb phosphorus from fertilizer located at various depths in the soil is modified by soil moisture. With sugar beet plants watered well, uptake of phosphorus was affected slightly by fertilizer placement, whereas with less irrigation, placement in bands at a depth of 4 inches was more effective than surface broadcast application (40). Others (29, 93, 95, 113) observed benefits of deep band placement of fertilizer in a relatively dry season. Robertson _et al_. (113) found that subsoiling alone, placement of fertilizer and/or lime 14 inches deep increased corn yields when rainfall was normally distributed. However, no benefit was obtained from deep fertilizer placement when there was a heavy rainfall during early growth period. Work by Patrick _et al_. (95) indicated that the subsoil conditions were unfavorable for root penetration, deep tillage and deep placement of fertilizer increased corn yield. This led to shortening the periods of moisture stress between rains due to an increased use of subsoil moisture resulting from increased root activity. Root studies by Hall _et al_. (41) on Norfolk sandy loam and Cecil clay loam showed that after 7 weeks corn obtained 1/3 of its phosphorus from the surface 3 inches, 1/3 from an 8-inch depth and the rest from 13- and 18-inch depths.

In conclusion, benefits from fertilizer placement are dependent upon many variables. Complete understanding of all these variables and appraisal of the intensity of each of the factors will make it possible to develop and bring about more effective use of fertilizer.

Plant Population

During recent years, many investigations have been made concerning the effect of plant population on growth and yield of corn. The general findings suggest that higher than average yields are obtained only with higher than average planting rates. Higher than average plant populations require higher than average fertility.

In numerous experiments there were greater increases in grain production from high populations at high fertility levels than from high populations at low fertility levels (21, 27, 46, 62, 69, 88, 96, 121, 139, 149). Krantz and Chandler (69) stated that considering ear size as well as yield, the best stand for the prolific hybrids appeared to be 4,000, 7,000, and 10, 000 to 13, 000 plants per acre at low, medium, and high nitrogen levels, respectively. Jordan **et al**. (62) compared the behavior of corn under two plant populations at three nitrogen levels in Mississippi. With 4,000 plants per acre, the first 60-pound increment of nitrogen resulted in a significant yield increase while the yield increase was moderate for the second 60-pound increment. Corn yields were increased significantly over the entire nitrogen range with 12,000 plants per acre. Pendleton et al. (96), in an experiment involving 9 corn hybrids on two soils, found that a population of 16,000 plants per acre gave the highest average yield on highly productive soils, while 12,000 plants per acre gave the highest average yield on soils of medium productivity.

Colville and McGill (16) found slight differences in yields among population rates of 16,000, 20,000, and 24,000 plants per acre over 5 years at 7 locations in Nebraska. Termunde et al. (136) compared the behavior of 8 corn hybrids grown at populations of 4,000 to 32,000 plants per acre at 4 sites having different yield potentials. They observed that the optimum plant spacing for maximum grain yield from a given hybrid appeared to be characteristic of that hybrid. They obtained maximum plant production and grain yields at populations of 12,000 to 16,000 plants per acre. At higher densities, grain production declined rapidly while forage yield was comparatively unaffected.

Rickey (110) summarized experiments with open-pollinated varieties in the United States and concluded that optimum planting rates were lowest for genetically large plants, low soil moisture supply, and low soil productivity.

The differential response of corn varieties and hybrids to planting rates has been reported by many workers (6, 45, 49, 81, 143). One may conclude that corn hybrids with similar yield potentials at normal spacing may differ widely in performance at high populations and fertility levels. Duncan (27) found that variations in yields among three hybrids at any population were very small at low fertility levels whereas at high fertility levels variations in yields due to plant population became more evident.

The main factor causing hybrid and spacing interaction seems to be the variation in the capacities of hybrids to utilize light efficiently. Numerous experiments (66, 99, 100) have shown that light was the major factor in reduction of corn yield as plant density was increased. The grain yields of maize hybrids at high plant population have been related to their tolerance to shading (89, 134). Moss and Stinson (89) observed that when corn was grown under 50 per cent normal light at high plant densities the grain yields of intolerant and tolerant hybrids were reduced 88 and 50 per cent, respectively. Failure of plants to form silks or delayed silking was more prevalent in the intolerant than tolerant hybrids. Knipmeyer et al. (66) found that reduction in light intensity was associated with an increase in nitrate and a decrease in dry matter and sugar content of the corn plant. Prine (99) concluded that the lower leaves of maize in dense stands did not receive sufficient light for synthesizing enough food for respiration and therefore photosynthates were translocated from the grain into these leaves.

Research in Florida in spacing and nitrogen fertilization of corn prior to 1956 showed that plant populations in excess of approximately 6,000 plants per acre and nitrogen in excess of 60 pounds per acre as side-dressing did not result in a significant increase in corn yield (13, 45, 51, 144). Wofford et al. (149) found that increasing the planting rate did not increase corn yields at low nitrogen levels. However, at high nitrogen levels, yields were increased when planting rates were increased. They concluded that changing plant population had a greater influence on yield than changing nitrogen levels. Norden (91) observed an increase in the mean grain yield from 105.5 bushels per acre to 132 bushels per acre in 1960 as plant population was increased from 5,000 to 25,000 plants per acre. In an experiment involving the effects of spacing and planting rates on the yields of several corn hybrids and varieties, Chapman (14) was not able to increase yield with increasing plant population over 20,000 plants per acre.

In the paper by Dungan et al. (28) in which they presented an excellent discussion on corn plant population and productivity, they conclude that, "although many experiments have been conducted to determine how thick to plant corn, the question is not fully answered. Because of the nature of the problem, it perhaps can never be answered once and for all. Each growing season is different from all that have preceded it; the productivity of the land is undergoing constant changes, and the inherent make-up of the current hybrids is undergoing modification. This does not mean that selection of rate of planting is a hopeless riddle or that population is not an important matter. On the contrary, it is intensely important and if the corn grower applies all the information he can gain on the subject and makes full use of his experience and judgment, he can make real strides in increasing the grain-yielding efficiency of his fields."

Effect of Soil Moisture on the Growth and Nutrition of Corn

More and more attention is being directed toward the water needs of crops. Lack of sufficient moisture is one of the major limiting factors of crop production, not only in the arid and semi-arid areas but also in the humid eastern states. Irrigation has been practiced frequently in the arid regions as the means of overcoming moisture stress and it is becoming a general operation in the subhumid and humid regions.

Soil conditions, cultural and soil management practices, location and environmental factors affect the amount of water needed to produce a corn crop. Average water consumption by corn in Nebraska has been reported to be about 0.30 inch per day over 15 to 20 day intervals during the last of July and throughout August (108).

Nutrient uptake by plants may be influenced by soil moisture supply. Total nutrient uptake will be suppressed by soil moisture stress where growth is limited materially by lack of water. However the effect of decreasing soil moisture supply is not necessarily of the same magnitude for growth as absorption of nutrient. Richards and Wadleigh (109) stated that data from most experiments show that reducing soil moisture supply is associated with an increase in the nitrogen percentage, a decrease in potassium percentage, and varied effects on calcium, phosphorus and magnesium percentages in the plant tissues. They make the following general statement: ". . . It is well established that when growth of plants is limited by soil moisture supply, nitrogen tends to accumulate within the plant because the rate of entry is approximately maintained in conjunction with the decreased rate of utilization in the growth processes. The general tendency for potassium content to be relatively low in plants on the drier soils shows that rate of K decreases to a greater degree than does rate of utilization in those slower growing plants. . . . The effect of soil moisture on phosphate nutrition is far less consistent than is observed for nitrogen and potassium. . . . The available evidence consistently shows magnesium to be relatively high in the plants growing under restricted moisture supply. . . . Since entry of calcium and magnesium in plants tends to vary reciprocally, it could be inferred that characteristically low potassium content of plants with inadequate moisture supply would be accompanied by a relatively high content of calcium." Miller and Duley (85) found that as an average of all cases, minimum moisture content gave higher nitrogen percentages and higher mineral content than where optimum moisture was applied during any period of growth. Similar results have been reported by Jenne *et al*. (55). In contrast, Greaves and Nelson (38) found that in corn grain the percentages of calcium, phosphorus and potassium were lower and that of nitrogen was higher in nonirrigated corn than in irrigated corn.

Mederski and Wilson (82) found that the percentages and total amounts of phosphorus, potassium, and magnesium in corn plants were increased with an increase in soil moisture. The increases in the percentage of phosphorus and potassium were linear at low relative humidity (50 per cent). Magnesium percentage increased linearly at high relative humidity (98 per cent). Olsen *et al*. (94) observed that uptake of phosphorus by corn seedlings decreased exponentially as soil moisture tension was increased. The uptake increased linearly with soil moisture content.

It seems logical to assume that variation in nutrient status of soils, variation in the varieties and hybrids and differences in growth stage when inadequate soil moisture is a limiting factor accounts for discrepancies in the results reported by numerous workers concerning the influences of limited soil moisture supply on the nutrient concentration in plants.

Several workers (2, 65, 120) have indicated the necessity of sufficient soil moisture for promoting growth and increasing corn yields. It has been reported that yield of corn is closely related to subsoil moisture supply at the beginning of the season (73). Bartholomew (2) concluded that under Arkansas conditions corn yields were affected more by limited summer moisture supply than by fertilization. Irrigation alone led to higher yields than fertilization, either with or without irrigation. Peters (98) studied the effects of soil moisture stress and soil moisture content on growth of corn under different relative humidities. He observed that growth of corn grown in silty clay loam or a mixture of 33 per cent loam and 67 per cent sand was markedly reduced by high soil moisture stress at low relative humidity, whereas at high relative humidity, growth was affected very little.

It seems that the effect of soil moisture on growth and yield of corn differs on various soils. Results reported by Schwab *et al*. (120) indicated an increase in corn yields brought about by irrigation on soils with low and high water holding capacity were 34 and 21 bushels per acre, respectively. In Indiana Luetkemeier and Kohnke (78) stated that although moisture supply was sufficient throughout the growing season, supplemental irrigation was a sound practice for coarse-textured soils. They concluded that factors other than soil moisture might be limiting plant growth on fine-textured soils, thus making irrigation practices questionable.

Several workers have reported the effects of soil fertility upon yield and water consumption of corn (9, 43). In general, water requirements of corn were lower on high fertility soils than on low fertility soils. Montgomery and Kiesselbach (87) and Kiesselbach (64) showed a reduction in water requirements of corn plants by the addition of fertilizers to the soil. On poor soils, addition of fertilizer lowered the water requirements of maize by one-half, whereas the effect was slight on highly productive soils. Widtsoe (147) reduced the water requirement of corn through the application of manure and nitrogen fertilizers and Kelley (63) was able to decrease the water requirement for each ton of hay through application of phosphorus to low phosphorus soils under irrigation conditions. Hanks and Tanner (43) obtained an increase in the yield of corn and oats per inch of water with nitrogen additions.

The response of corn to nitrogen was studied under various water tables in the greenhouse by Shalhevet and Zwerman (122). They observed that dry weight of top and roots and height of plants under fluctuating or high water table were greater with nitrogen than without nitrogen. The results of later work by Shalhevet and Zwerman (123) indicated that lack of oxygen and available nutrients were major factors restricting plant growth in the saturated soils. Data from numerous experiments indicated that corn was especially sensitive to soil moisture stress at about the tasseling and silking period and emphasized the importance of adequate moisture during these periods (22, 23, 37, 48, 70, 85, 116, 125, 131).

Miller and Duley (85) arbitrarily divided the growing season of corn into 30-day periods. Optimum (28 per cent) and minimum (13 per cent) soil moisture levels were kept in all possible combinations within these periods of growth on a fairly fertile soil of coarse silt loam texture. They found that the plant was most sensitive to moisture stress during the period of silking and ear growth as far as grain yield was concerned. Total dry weight of the plant was affected greatly by moisture supply during the second 30-day period of growth (from the time plants set their ninth leaves until tasseling). When plants were exposed to moisture stress early in the growing season, vegetative growth was stunted slightly. However, plants recovered if moisture levels were favorable during the last two periods, but a moderately large reduction in grain yields was observed and time for maturity was prolonged. Howe and Rhoades (48) tested thirteen irrigation treatments on very fine sandy loam to study the importance of maintaining a low soil moisture tension during various stages of maize development. They found that a low soil moisture tension throughout a growing season was essential for maximum yields. When a high soil moisture stress was alleviated by irrigation during the tasseling period, grain yields were increased appreciably, but the yields were markedly lower than when a low soil moisture stress was maintained throughout the tasseling and silking periods. Robins and Domingo (116) reported reduction of 22 and 50 per cent in corn yields as the result of moisture deficits for periods of one to two and four to six days, respectively, during tasseling and silking periods.

In an experiment by Larson *et al.* (70) low amounts of irrigation water preceding pollination followed by large amounts of water during pollination and low quantities for the rest of the growing season produced as much corn as large quantities of water during the entire growing season.

Numerous experiments including those of Howe and Rhoades (48), Miller and Duley (85), and Robins and Domingo (116), indicated that moisture deficiency throughout the growing season resulted in stunted plants having short internodes, more root growth in relation to top growth, poor leaf growth, delayed silking and tasseling, delayed maturity and small, poorly filled ears.

It is logical to conclude that corn cannot be grown profitably without irrigation in arid areas. Irrigation changes corn from a marginal to a profitable crop in semi-arid regions. It removes the ever present hazard of drought in the subhumid and humid sections.

EXPERIMENTAL METHODS

The experimental site is located at the University of Florida Beef Research Unit, about 11 miles northeast of Gainesville, on Leon fine sand. The profile characteristics of the Leon series are as follows:[2]

Inches	
0 - 5	Dark gray (10yR 4/1) fine sand, single grained with some light gray sands to give salt and pepper appearance.
5 -12	Light gray (10yR 6/1) fine sand, single grained.
12 -14	Black (10yR 2/1) fine sand, commonly massive, firm to friable when moist.
14 -20	Dark brown (10yR 3/3) fine sand, single grained.
20 -24	Dark grayish brown (10yR 4/2) fine sand, single grained.
24 -36	Grayish-brown (10yR 5/2) fine sand, grading to light brownish gray and to light gray with increasing depth.

The drained tract is 300 feet wide and 400 feet long. The Leon soil in this area has an organic pan beginning at depths of 10 to 20 inches. A fine sandy loam layer is generally in the area beginning at depths of 30 to 48 inches. Depths to sandy clay loam which apparently underlies the whole area varies from about 60 inches to greater than 72 inches.

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[2] Supplied by Mr. R. G. Leighty, Associate Soil Surveyor, Florida Agricultural Experiment Station, Gainesville, Florida.

The land was cleared, left idle for several years, and in 1958 was leveled with a road grader to a 0.25 per cent slope in north to south direction with some movement of topsoil to the south end. Plastic mole drains were installed in a 10-foot spacing at a depth of 18 inches in one third of the plot and at 30 inches in the remainder. In 1960 corn was planted with a uniform light application of fertilizer in the row. No corn was harvested due to the poor growth which resulted from the lack of fertilizer, lime, and weed control. In 1961, the plastic tile was replaced by clay tile spaced 20 feet apart at depths as described above.

A 12 x 3 x 2 factorial(fertilizer rate and placement pattern, plant population, and corn hybrid) experiment was conducted in 1963. Prior to fertilization, 18 soil samples were taken with a 1-inch diameter tube from each block in 6-inch increments to a depth of 18 inches. Soil pH and extractable calcium, magnesium, phosphorus, and potassium were measured by the University of Florida Soil Testing Laboratory using methods described by Breland (7).

On March 21, 1963, high calcic limestone and dolomite were broadcast at rates of 1800 and 2866 pounds per acre, respectively. The dolomite contained 0.5 per cent FTE 503[3] as a source of iron, manganese, zinc, boron, and copper.

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[3] A fritted source of trace elements manufactured by the Ferro Corporation, Cleveland, Ohio.

These materials were mixed to depths of 4 to 6 inches by disking. The experimental site was located at the south end of the drained tract. Blocks 1 and 2 (100 x 225 feet on an 18 inch water table) were separated from blocks 3 and 4 (100 x 225 feet on a 30-inch water table) by 100 feet. The size of individual plots was 10 x 15 feet oriented north-south with the rows oriented in the same direction. Plots were located so that one edge terminated over tile and the other midway between tiles.

The treatments consisted of 12 fertility combinations (Table 1), 3 planting rates (19,360, 27,922, and 38,720 plants per acre) and 2 corn hybrids (Florida 200 and Dekalb 805).

After locating the plots and rows, a complete fertilizer analyzing 5-10-15 ($N-P_2O_5-K_2O$) was hand-applied on March 25 to the soil surface in various rates and placement patterns (Table 1). The fertilizer was placed so that the corn row would be in the center of the fertilized band. During the course of fertilization, relatively strong winds interrupted fertilizer application and some fertilizer loss and nonuniform patterns of application resulted. After the fertilizer was applied, the soil surface was sprinkler irrigated to minimize soil and fertilizer blowing. The fertilizer was incorporated to the desired depths by using a garden rotavator. After cultipacking, Florida 200 hybrid corn (long season - large stalk) and Dekalb 805 hybrid corn

TABLE 1

Fertilizer rate and placement pattern in corn experiments on Leon fine sand, 1963.

Fertility treatment no.	Fertilizer rate (pounds per acre)				Area fertilized (per cent)	Depth of placement (inches)
	Total[a]	N	P	K		
1	0	0	0	0	0	0
2	4,000	600	176	500	100	6
3	2,000	300	88	250	100	6
4	1,000	150	44	125	100	6
5	2,000	300	188	250	50	6
6	2,000	300	88	250	100	3
7	1,000	150	44	125	50	6
8	1,000	150	44	125	100	3
9	500	125	22	63	50	6
10	2,000	300	88	250	25	6
11	1,000	150	44	125	25	6
12	500	125	22	63	25	6

[a] Mixed fertilizer, approximately 15-4.37-12.45 (N-P-K).

(short season - small stalk) were planted on March 31 and April 1, respectively, using planting pattern of 18 x 18, 15 x 15, and 9 x 18 inches for the three plant populations. The plots contained 6 rows in 18-inch spacings and 8 rows in the 15-inch spacing. Atrazine at the rate of 4 pounds per acre was used for weed control. Any missing plant in the two center rows was replaced by a single corn seedling grown outdoors in a small peat pot.

Maintenance practices consisted of side dressing the corn with ammonium nitrate to bring the ratio of applied nutrients to 15-10-15 ($N-P_2O_5-K_2O$) at the knee-high stage of growth. DDT (5 per cent dust) was used for budworm control as needed. Rainfall was sole source of water. The water table was controlled near the 18 and 30 inch depths by passing water through the tiles continuously. Meanwhile, hand-pulling and hoeing aided in the control of weeds.

A recording rain guage was installed near the experimental site. A record of weekly rainfall was kept for the period March 1, 1963 to June 29, 1963. The above-ground portions of Dekalb 805 and Florida 200 were harvested July 29 and August 8, respectively. The two center rows were selected for harvest with 9 feet of row being used from the plots with 18-inch row spacings and 10 feet of row from the plots with 15-inch row spacings. Plants harvested per plot were 12, 16, and 24 for the plant populations of 19,360, 27,922, and 38,720, respectively. Any plant which looked shorter than average and appeared to be a transplant was not included; instead, a nearby plant in an adjacent row was selected randomly. Ears of plants from each plot were removed, counted, placed in cabbage bags and dried at 60-70°C. Corn stalks were bound and left to air-dry in an open shelter near the experimental site. The shelling percentage was determined on randomly-selected corn ears from ten plots for each hybrid. The moisture content of representative samples of corn grain was determined on a Steinlite moisture tester. Five plots for each hybrid were selected at random. The grain yields were adjusted to bushels of shelled corn per acre at a 15 per cent moisture on the basis of calculated shelling percentage of both hybrids. Three to four corn ears representative of each bag were ground through a Wiley mill twice, with two different screen sizes, and stored for chemical analysis.

When the corn stalks were air-dry, they were weighed and passed through a silage chopper. Subsamples were dried at 60-70°C for moisture determination. The samples were then ground in a Wiley mill and stored for chemical analysis. During the period August 29, 1963, to February 24, 1964, 12 soil samples per plot in blocks 3 and 4 and 9 soil samples per plot in blocks 1 and 2 were taken in 6-inch increments to a depth of 18 inches. A 1½ inch diameter tube was used for sampling at random in the rows. The soil samples were air-dried, passed through a 2 millimeter sieve and submitted to the University of Florida Soil Testing Laboratory for the following analyses: pH, and extractable calcium, magnesium, phosphorus and potassium.

Plant samples dried at 65°C for 48 hours, were dry-ashed as described by Chapman and Pratt (12) using one and two gram samples for grain and forage, respectively. Phosphorus was determined colorimetrically and potassium with the Beckman DU flame photometer (53). The flame and colorimeter were calibrated with standard solutions of known potassium and phosphorus concentrations.

An analysis of variance was made on the combined data from the two water tables for corn grain, forage and total dry matter yields and phosphorus and potassium uptake by corn ear, forage and total plant. Also, the relationship of yields of dry matter to fertilizer rate and plant population was evaluated by regression analysis.

RESULTS AND DISCUSSION

Field and laboratory data collected before and throughout the experiment were organized into three groups on the basis of the nature of the response measured.

Environmental Conditions

The extractable soil nutrients, water tables and rainfall were the only environmental data collected.

Soil Analyses

The results of soil analyses prior to the experiment and after completion of the experiment are given in Tables 2 and 3.

The fertility level was low throughout the soil profile at the beginning of the experiment. In general, potassium, calcium and magnesium contents decreased with depth, while pH tended to increase.

The fertility level of the soil after corn harvest was still low in the control plots (except for calcium and magnesium which were added to all plots). Soil pH and the amounts of extractable phosphorus, potassium, calcium and magnesium usually decreased with depth. In general, potassium and magnesium moved through the profile to depths of 12 to 18 inches and possibly more, while calcium

TABLE 2

Nutrient status of Leon fine sand at the beginning of corn fertility experiment on water table control plots, 1963.

Block	Depth, in.	pH	Extractable nutrients, lbs. per acre[a]			
			P	K	Ca	Mg
1	0 - 6	4.6	1	29	372	59
	6 -12	4.8	1	15	303	31
	12 -18	5.0	2	12	120	17
2	0 - 6	4.6	1	9	150	5
	6 -12	4.7	1	6	65	3
	12 -18	4.8	1	10	137	8
3	0 - 6	4.9	1	22	130	7
	6 -12	4.9	1	21	125	3
	12 -18	5.2	1	15	50	2
4	0 - 6	4.5	2	36	230	32
	6 -12	4.8	2	27	115	14
	12 -18	5.2	2	16	90	15

[a] Nutrients extracted by acid (pH 4.8) ammonium acetate.

TABLE 3

Extractable nutrients in Leon fine sand in relation to depth and fertility treatments after termination of experiment on water table control plots, 1963.

Fertility treatment[a]	pH	Extractable nutrients, lbs. per acre			
		P	K	Ca	Mg
			0 - 6 in.		
Check	5.9	3	35	710	129
4/100	5.6	17	95	754	73
2/100	5.7	9	72	739	94
1/100	5.9	7	69	827	138
2/50	5.6	11	86	763	94
2/100, 3 in.	5.9	10	79	801	114
1/50	5.9	9	72	873	148
1/100, 3 in.	5.9	7	65	847	141
0.5/50	6.0	5	51	857	137
2/25	5.8	10	79	833	116
1/25	5.9	6	56	774	116
0.5/25	5.9	6	57	801	144
			6 - 12 in.		
Check	5.2	2	16	178	41
4/100	5.1	5	35	224	36
2/100	5.2	2	26	224	42
1/100	5.4	2	25	257	53
2/50	5.3	2	30	256	46
2/100, 3 in.	5.3	2	30	256	46
1/50	5.2	3	28	288	57
1/100, 3 in.	5.3	2	26	262	52
0.5/50	5.4	2	22	265	51
1/25	5.2	2	23	188	41
0.5/25	5.2	2	22	203	48

TABLE 3 (Continued)

Fertility treatment[a]	pH	Extractable nutrients, lbs. per acre[b]			
		P	K	Ca	Mg
		12 - 18 in..			
Check	5.1	1	20	89	27
4/100	4.9	3	34	94	29
2/100	5.0	1	21	62	27
1/100	5.0	2	19	82	32
2/50	5.6	2	22	87	31
2/100, 3 in.	5.1	2	23	100	32
1/50	5.0	2	21	90	24
1/100, 3 in.	5.1	2	21	92	31
0.5/50	5.0	2	16	75	30
2/25	5.0	2	23	96	27
1/25	4.9	2	18	80	28
0.5/25	5.0	1	18	95	42

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] Nutrients extracted in acid (pH 4.8) ammonium acetate.

tended to reach only into the 6- to 12-inch soil layer. Potassium leached more readily than calcium due to the lower bonding energy of potassium on the soil exchange complex.

Water Table

Attempts made to maintain the water table at depths of 18 (blocks 1 and 2) and 30 (blocks 3 and 4) inches were not thoroughly successful. Average depths to water tables, measured at three locations in blocks 1 and 2 and four locations in blocks 3 and 4 for the period of approximately six months (from December 29, 1962 to June 29, 1963), were 22, 20, 29 and 32 inches from the soil surface for blocks 1, 2, 3 and 4, respectively. Tiles spaced at 20-feet intervals kept the water table from rising more than a few inches following a rainfall.

Rainfall

The rainfall distribution data in 5-day and monthly intervals from March through July 1963 are shown in Table 4. Considerably higher precipitation was recorded in June and July than in March, April and May. Also intensity of precipitation varied considerably within a given month. In March and April, there was no rain for periods of 3 to 4 weeks with as little as 0.05 inches to as high as 2.75 inches with comparatively much shorter intervals of rainless periods.

TABLE 4

The rainfall distribution from March through July 1963 at the water table control plots.

Period, days	Rainfall, in.				
	March	April	May	June	July
1 - 5	1.60	0.00	0.50	2.35	2.75
6 - 10	0.95	0.67	0.00	0.05	1.35
11 - 15	0.00	0.06	0.00	0.00	0.00
16 - 20	0.00	0.00	0.00	0.30	2.90
21 - 25	0.00	0.00	3.90	4.60	0.95
26 - 31	0.00	1.35	0.00	1.40	0.50
Total	2.55	2.08	4.40	8.70	8.45
Days with rainfall	4	3	4	12	8

Yield of Dry Matter

Grain and total dry matter yields were of primary interest as criteria of response. The term "forage" was used to refer to the total dry matter less corn ears. Complete detailed data are presented in Tables 27, 28 and 29, and the corresponding analyses of variance appear in Tables 21 and 22. Tables of analysis of variance will be discussed in relation to the three main effects, namely, fertility, plant population and hybrids. Effects that are statistically significant (using overall error term) at 5, 1 and 0.1 per cent level of probability will be referred to as significant, very significant and highly significant, respectively.

Fertility

Fertility as a main experiment variable was highly significant for grain, forage and total dry matter. This was expected due to the wide range in rate and method of fertilizer application. A better understanding of fertility treatment significance can be obtained by using the eleven degrees of freedom to make eleven comparisons (Table 20). Yield data for eleven comparisons are given in Table 5 and three of the most important comparisons will be discussed in detail followed by brief evaluation of the others.

There were no significant differences in grain, forage and total dry matter yields between the treatments where the fertilizer was broadcast and incorporated to depths of 3 and 6 inches. There is some doubt as to the actual depth of fertilizer application in this experiment. A garden rotavator was used to incorporate the fertilizer to the desired depth. However, due to unevenness of the soil surface, variations in soil texture and structure, and limitation of machine, it was impossible to incorporate the fertilizer uniformly at the specified depths.

The average grain, forage and total dry matter yields obtained from 50 per cent localized placement of fertilizer did not differ significantly from those produced by placement 25 per cent. Relatively strong winds interrupted the hand application of fertilizer when the plots were being established and resulted in some loss and nonuniform distribution over the soil surface. This factor combined with lack of sufficient precision on the part of laborers in dressing fertilizers in the planned patterns could have influenced the results obtained. Jensen and Pesek (57, 58, 59) found that nonuniform application of fertilizers resulted in reduced yields of corn, and they developed mathematical formulas which predict these reductions.

There was a significant difference in yields of grain, forage and total dry matter between broadcast and localized

TABLE 5

Grain, forage and total dry matter yields in relation to various fertility treatment comparisons on Leon fine sand, 1963.

Fertility treatment comparison	Yield: Grain	Yield: Forage	Yield: Total dry matter
	bu./acre	lbs./acre	lbs./acre
Broadcast 3 in.			
1000	110	6939	13990
2000	127	8132	16224
Average	118	7538	15107
Broadcast 6 in.			
1000	117	7020	14499
2000	123	8207	16076
4000	111	8320	15399
Average	117	7849	15325
Placed 50 per cent			
500	89	5972	11644
1000	111	6794	13910
2000	127	8125	16234
Average	109	6964	13929
Placed 25 per oent			
500	82	6289	11551
1000	108	7042	13940
2000	125	8284	16255
Average	105	7205	13915
Broadcast 3 and 6 in.	118	7723	15238
Placed 25 and 50 per cent	107	7084	13922

fertilizer application. There are some reasons to believe that the difference in response was magnified somewhat due to the fact that the group of broadcast treatments included higher rates of fertilization than the group of placed treatments. The 4,000 pounds rate of fertilization was included only in the broadcast group while the 500 pounds rate was included only in the placed group of treatments. However, if the differences were real, it may reflect a better late season nutrient status in a larger part of the root zone for the broadcast treatments.

The better response obtained with broadcast than localized placement of fertilizer is in contrast to the finding by others (84, 90, 97, 101, 135) of a better response with band placement of fertilizer than with broadcasting. In the Netherlands, Prummel (101) found that maize was markedly stimulated by band placement of superphosphate; the crop grew more rapidly, ripening was promoted and higher yields were obtained than with the broadcast dressing. He stated that phosphate applied in bands was about 2.9 times as effective as broadcasting for corn. DeWit (24) stated that more yield could be obtained with localized placement than with broadcasting for light fertilizer dressing. However, with heavy fertilization, broadcasting proved to be as good or even better than banding.

Steenbjerg (133) also introduced a theory on fertilizer placement. He stated that if the relation between yield and broadcast fertilizer rate was a sigmoid curve, then the point of greatest positive slope on the convex portion of the curve with reference to the origin represents the optimum rate of fertilization. Thus, for best yields from less than optimum amounts of fertilizer, the producer should place the fertilizer over a fraction of the soil area equal to the ratio of the amount of available fertilizer to the optimum amount. One can conclude from this theory that if the quantity of fertilizer is limited, higher response can be obtained from localized placement than broadcast dressing.

In the present experiment, there were significant differences where check was compared with the remainder of the fertility treatments and where the 1000 and 2000 pound rates of fertilization (broadcast, incorporated to 3 inches) were compared. This was expected due to wide variation in rates of fertilization.

With broadcast treatments, the response was quadratic for forage and total dry matter. However, when the fertilizer was placed 25 per cent, the responses became quadratic for grain and linear for forage and total dry matter. This could have a practical significance if corn was to be used for silage or forage in which case even higher rates of fertilization might be justified. Grain, forage and total dry matter showed only a linear response with 50 per cent localized placement, indicating a consistent linear increase in corn yields with fertilization.

The differences in types of response obtained for grain with fertilizer broadcast and placed 25 or 50 per cent might be attributed, as indicated previously, to higher rates of fertilization included in broadcast group than in the localized placement group. However, the reason for the differences between 25 and 50 per cent placement are not clear.

Plant Population

It is evident from Table 6 that overall average grain yield was increased up to the medium population and decreased thereafter while forage and total dry matter production were increased with planting rate. Grain yield at the low plant density was significantly higher than that at the highest population whereas the reverse was true for forage and total dry matter production. Plant population did not interact either with fertility or hybrid (Table 21).

Hybrid

The overall average grain production of DeKalb 805 was significantly more than that of Florida 200 (Table 6). However, the latter hybrid produced significantly higher forage and total dry matter than the former one.

TABLE 6

Grain, forage and total dry matter of DeKalb 805 and Florida 200 in relation to plant population on Leon fine sand, 1963.

Hybrid	Yield 1[a]	2	3	Average
	Grain, bu./acre			
DeKalb 805	115	117	109	114
Florida 200	97	104	87	96
Average	106	111	98	105
	Forage, lbs./acre			
DeKalb 805	4598	5678	6737	5671
Florida 200	7419	8699	9145	8421
Average	6009	7189	7941	7046
	Total dry matter, lbs./acre			
DeKalb 805	11990	13197	13810	12999
Florida 200	13565	15269	14677	14504
Average	12777	14233	14244	13751

[a] The plant population rates were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

Grain production was probably limited by the cloudy weather conditions which occurred in June and July. It may be that Florida 200 was more sensitive than DeKalb 805 to reduced sunlight. In addition, some of the yield differences between the two hybrids can be attributed to the fact that Florida 200 stalks were slender and tall and lodged to a greater extent than DeKalb 805 during heavy rainfall in July. Furthermore, since DeKalb 805 was harvested before Florida 200, laborers, while carrying the former stalks out of the field, broke a good number of the latter plants by walking through unharvested plots.

There was a significant interaction between fertility and hybrid for grain and forage yields (Table 21). However, this interaction was insignificant when it was tested against its own error.

A more detailed study of the data was made by regression analyses. Presentation and discussion of these data are made under the two subheadings: grain, and forage and total dry matter.

Grain

The dependence of grain yield upon plant population and fertilizer rate and placement pattern is shown in the following equations:

$$Y_{DB} = 110 + 58(X_1) - 19(X_1^2) \qquad (1)$$

$$Y_{DP} = 124 + 50(X_1) - 43(X_1^2) \qquad (2)$$

$$Y_{FB} = 93 + 38(X_1) - 12(X_1^2) \qquad (3)$$

$$Y_{FP} = -16 + 42(X_1) + 9(X_2) - 25(X_1^2) - 0.17(X_2^2) \qquad (4)$$

where Y is grain yield (bu./acre); the respective subscripts D, F, B and P are DeKalb 805, Florida 200, broadcast and localized fertilizer application (50 and 25 per cent); X_1 is rate of fertilizer in pounds per acre minus 1000 quantity divided by 1000 and X_2 is thousands of plants per acre.

Equations 1, 2 and 3 indicate that plant population had no effect on the grain yield. This is in agreement with results reported by Colville and McGill (16) who found slight differences in yields with 16, 20 and 24 thousand plants per acre over five years at seven locations in Nebraska. On the other hand, the presence of both X_1 and X_2 in equation 4 shows that the grain yield of Florida 200 was affected by plant population and fertilizer rate placed independent of each other. This is in agreement with the findings of Hammond and Robertson (42) with Florida 200 except that they found a significant interaction between plant population and fertilizer applied. However, their plant populations ranged from approximately 7 to 24 thousand plants per acre.

It is not quite clear why population had an independent effect on grain yield when fertilizer was placed and not when it was broadcast for Florida 200. It is also not clear why DeKalb 805 did not respond the same as Florida 200 to placed fertilizer.

The predicted relationships between yield and fertilizer rates are shown graphically in Figures 1 and 2. The differentiation of equation 1 and 3 with respect to X_1 showed that maximum yields of DeKalb 805 and Florida 200 (154 and 123 bushels per acre) were estimated to occur at nearly the same fertilization rates (2526 and 2583 pounds per acre broadcast).

It was expected that grain production in all cases would be affected by plant population independently or by interaction with fertilizer rate. In addition to Hammond and Robertson (42), many workers reported greater increases in grain from high population rates at high fertility levels than from high planting rates at low fertility levels (21, 27, 46, 62, 69, 88, 96, 121, 139, 149).

Based on the findings of Long (76), Loue (77) and Smith (129) the fertilizer rate at 2000 pounds per acre should have supplied nutrients adequate for 200 bushels of corn grain per acre. In this experiment, maximum yields of 144 and 125 bushels per acre for DeKalb 805 and Florida 200 were obtained with fertility rates ranging from 1000 to 2000 pounds per acre and plant population from 19,360 to

Figure 1. Relationship between grain yield and fertilizer rate (broadcast) for DeKalb 805 and Florida 200.

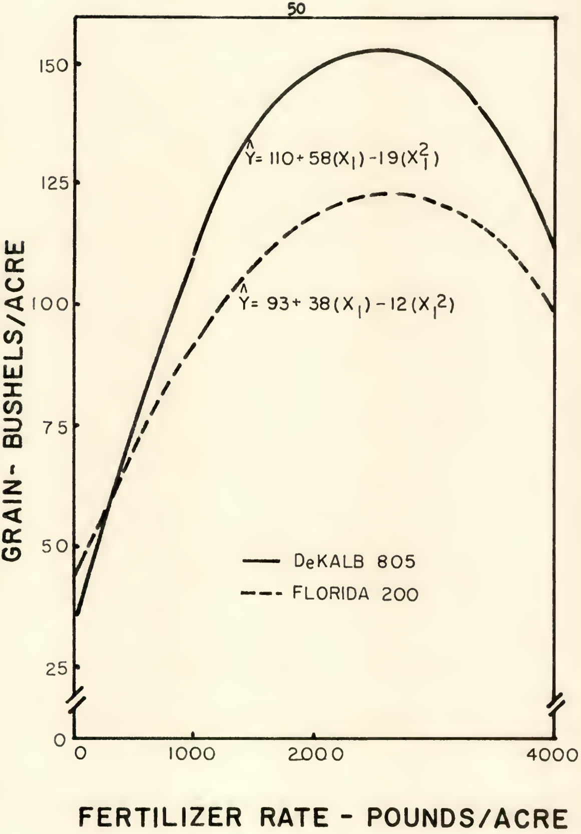
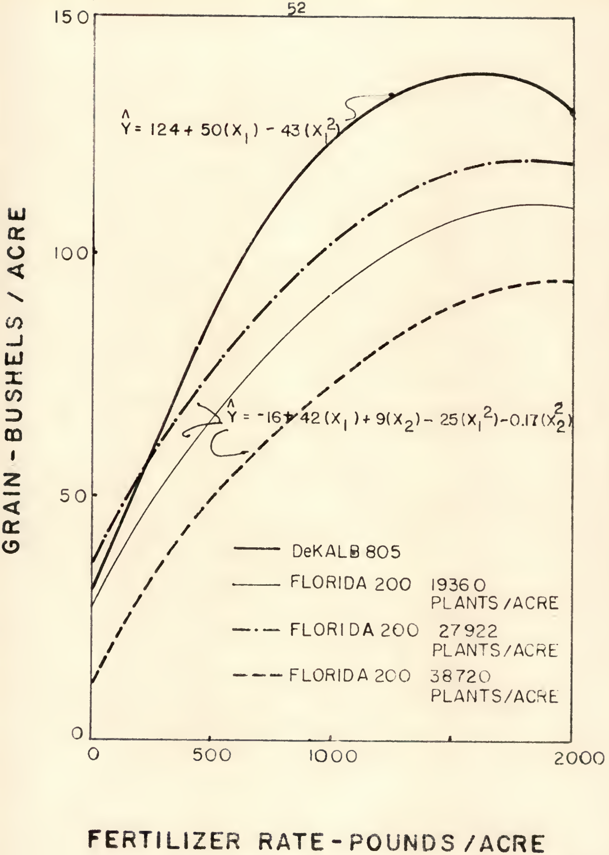

GRAIN - BUSHELS/ACRE
150
125
100
75
50
25
0
$\hat{Y} = 110 + 58(X_1) - 19(X_1^2)$
$\hat{Y} = 93 + 38(X_1) - 12(X_1^2)$
DeKALB 805
FLORIDA 200
0
1000
2000
4000
FERTILIZER RATE - POUNDS/ACRE

Figure 2. Relationship between grain yield and fertilizer rate (placed 25 and 50 per cent) for DeKalb 805 and Florida 200.


150
100
50
0
0
500
1000
2000
GRAIN - BUSHELS / ACRE
FERTILIZER RATE - POUNDS / ACRE
$\hat{Y} = 124 + 50(X_1) - 43(X_1^2)$
$\hat{Y} = -16 + 42(X_1) + 9(X_2) - 25(X_1^2) - 0.17(X_2^2)$
DeKALB 805
FLORIDA 200 19360 PLANTS / ACRE
FLORIDA 200 27922 PLANTS / ACRE
FLORIDA 200 38720 PLANTS / ACRE

27,922 plants per acre. At higher fertility levels, the yields of grain were reduced, suggesting that some factor other than nutrient deficiencies was limiting yield. In west Florida, Hutton __et al__., (52) found that fertility alone did not increase the grain yield beyond 110 bushels per acre. In North Florida, Thompson __et al__., (137) reported that, over a period of 12 years, corn yields averaged 65 bushels where 750 pounds of 8-10-8 fertilizer were used without irrigation.

__Forage and Total Dry Matter__

The relationships between forage and total dry matter yields and fertilizer rate and plant population were evaluated by regression procedures. The results are shown in the following equations:

$$(Y_{DB} = 2849 + 981(X_1) + 90(X_2) - 480(X_1^2) + 30(X_1X_2) \qquad (5)$$

$$(Y_{DP} = 2992 + 92(X_2) - 780(X_1^2) - 58(X_1X_2) \qquad (6)$$

Forage

$$(Y_{FB} = 5933 + 1802(X_1) + 67(X_2) - 748(X_1^2) + 38(X_1X_2) \qquad (7)$$

$$(Y_{FP} = -237 + 2796(X_1) + 584(X_2) - 1743(X_1^2) - 9(X_2^2) \qquad (8)$$

Total Dry Matter

$$(Y_{DB} = 12548 + 3946(X_1) - 1682(X_1^2) + 57(X_1X_2) \quad (9)$$

$$(Y_{DP} = 11680 + 4919(X_1) + 68(X_2) - 3534(X_1^2) \quad (10)$$

$$(Y_{FB} = 13730 + 3255(X_1) - 1496(X_1^2) + 70(X_1X_2) \quad (11)$$

$$(Y_{FP} = -1243 + 5468(X_1) + 1185(X_2) - 3342(X_1^2) - 20(X_2^2) \quad (12)$$

The notations are the same as previously given, except that Y varies with the particular group of equations.

Equations 5, 6, 7, 9 and 11 indicate that a significant interaction existed between the plant population and fertilizer rate. This is in contrast to what was concluded from the analyses of variance for forage and total dry matter (Table 21). However, one must remember that analyses of variance were made over the pooled data, whereas these regression equations were calculated only for a portion of the data. In the group of five equations with significant interactions, the fertilizer was broadcast with the exception of equation 6 where it was placed (50 and 25 per cent). In the other cases where the fertilizer was placed the regression equations 8, 10 and 12 did not contain a significant interaction between plant population and fertilizer rate. Again this difference in response to placed and broadcast fertilizer was probably related to the smaller rates of fertilizer used in the placed pattern than in the broadcast application. Equations 8 and 12 are shown graphically in Figures 3 and 4.

It is interesting to note the similarities among regression equations for grain, forage and total dry matter yields of Florida 200 when fertilizer was placed (equations 4, 8 and 12). The yields of dry matter were highest with the medium plant population (Figure 4). However, the response differences between high and medium plant densities for forage (Figure 3) and medium and low plant population for total dry matter were relatively small. This is somewhat in contrast to the way grain yields were related to plant population (Figure 2). The lowest grain yield was obtained with the highest plant population and there were comparatively larger differences in response between the three populations.

There was a quadratic effect for fertilizer rate in all cases. However equation 6 is the only case in which there was no significant linear effect for fertilization rate. The graph of this equation is shown in Figure 5. Differentiation of this equation with respect to the fertilizer rate, X_1, estimated that maximum yield was at 1700 pounds of fertilizer per acre for the low plant population. However, with high plant population, maximum yield was predicted at about 2400 pounds of fertilizer. Optimum rate of fertilization for medium plant density was about

Figure 3. Relationship between forage yield and fertilizer rate (placed 25 and 50 per cent) for Florida 200.

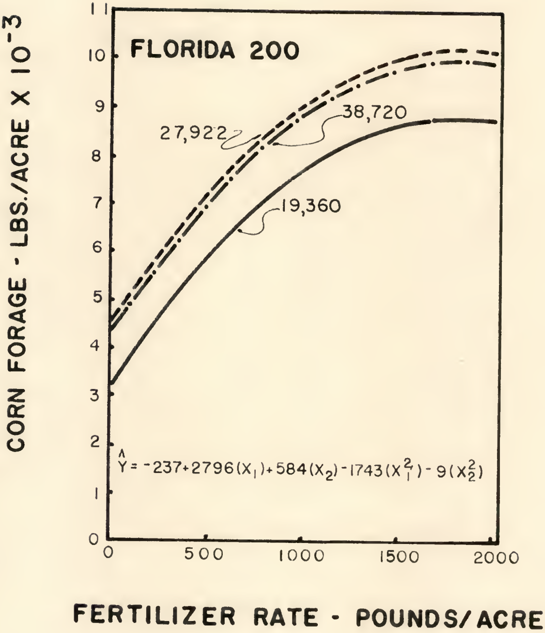

FLORIDA 200
27,922
38,720
19,360
Ŷ = -237+2796(X1)+584(X2)-1743(X1²)-9(X2²)
CORN FORAGE - LBS./ACRE X 10⁻³
0
1
2
3
4
5
6
7
8
9
10
11
0
500
1000
1500
2000
FERTILIZER RATE - POUNDS/ACRE

Figure 4. Relationship between total dry matter yield and fertilizer rate (placed 25 and 50 per cent) for Florida 200.

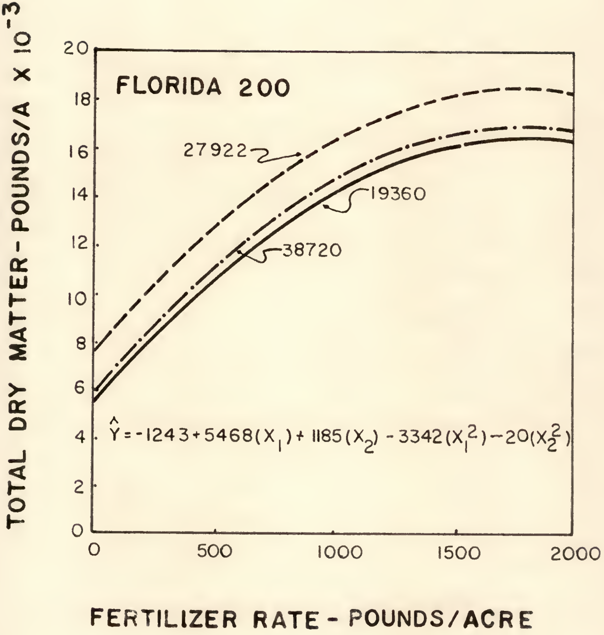
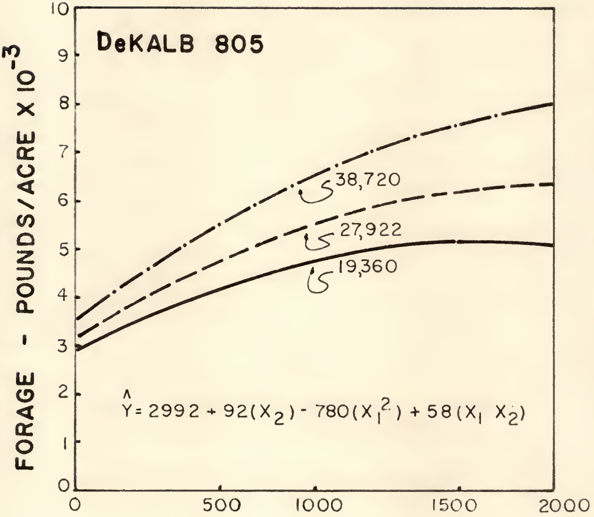

FLORIDA 200
27922
19360
38720
$\hat{Y}=-1243+5468(X_1)+1185(X_2)-3342(X_1^2)-20(X_2^2)$
TOTAL DRY MATTER - POUNDS/A X 10^{-3}
0
2
4
6
8
10
12
14
16
18
20
0
500
1000
1500
2000
FERTILIZER RATE - POUNDS/ACRE

Figure 5. Relationship between forage yield and fertilizer rate (placed 25 and 50 per cent) for DeKalb 805.



FERTILIZER RATE - POUNDS/ACRE

2000 pounds per acre. It is justified to assume that the plant population was not sufficient to make most efficient use of high fertilization. Also, since there was no quadratic effect for plant population, higher forage yields may have been obtained if higher planting rates had been used in this experiment.

Equation 10 was the only case in which there was neither a quadratic effect in plant population nor a significant interaction between fertilizer rate and plant population. Lack of significant quadratic effect for plant population in equation 10 and also in equations 5, 6 and 7 suggests that larger yields might be expected from plant populations higher than those used in this experiment. However, in the case of equations 5, 6 and 7, increases in plant population predicted greater yield increases when the fertilizer level was high than when low. In equation 10, the predicted increments of yield increase due to changes in plant population were the same at any level of fertilization. The graphical representations of equations 7 and 10 as shown in Figures 6 and 7 confirm this point further.

It is interesting to note that when fertilizer was broadcast, plant population did not have any effect on total dry matter yields of DeKalb 805 and Florida 200, though it significantly interacted with fertilizer rate (equations 9 and 11). Figure 8 is a graphical representation of equation 9. Differentiation of this equation with

Figure 6. Relationship between forage yield and fertilizer rate (broadcast) for Florida 200.

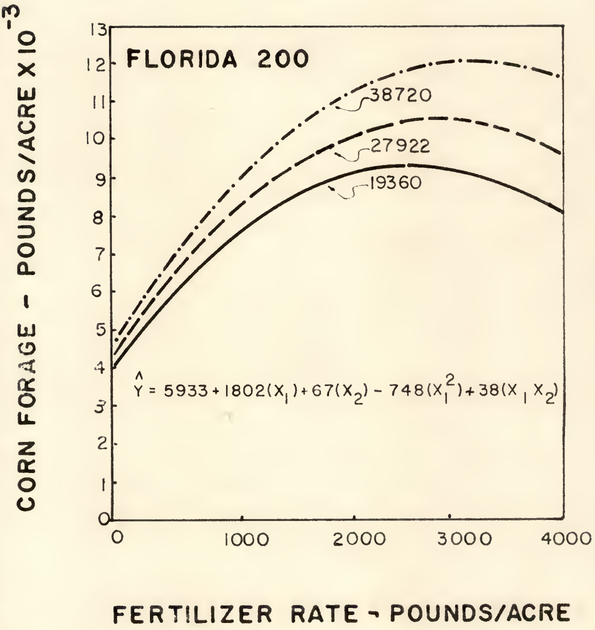

FLORIDA 200
38720
27922
19360
$\hat{Y} = 5933 + 1802(X_1) + 67(X_2) - 748(X_1^2) + 38(X_1 X_2)$
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0
1000
2000
3000
4000
CORN FORAGE - POUNDS/ACRE X 10^{-3}
FERTILIZER RATE - POUNDS/ACRE

Figure 7. Relationship between total dry matter yield and fertilizer rate (placed 25 and 50 per cent) for DeKalb 805.

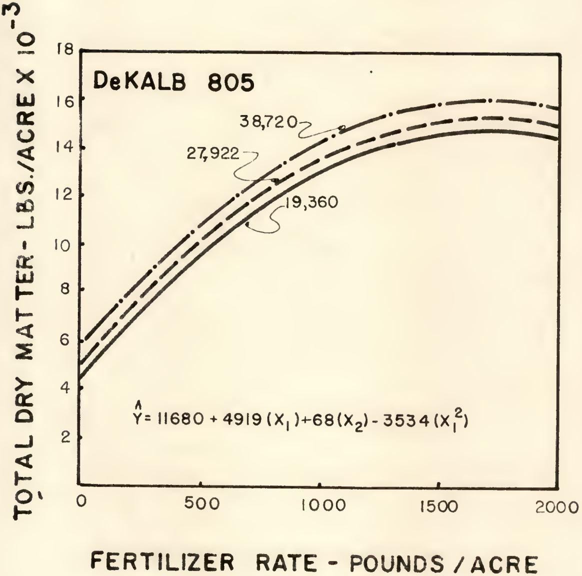
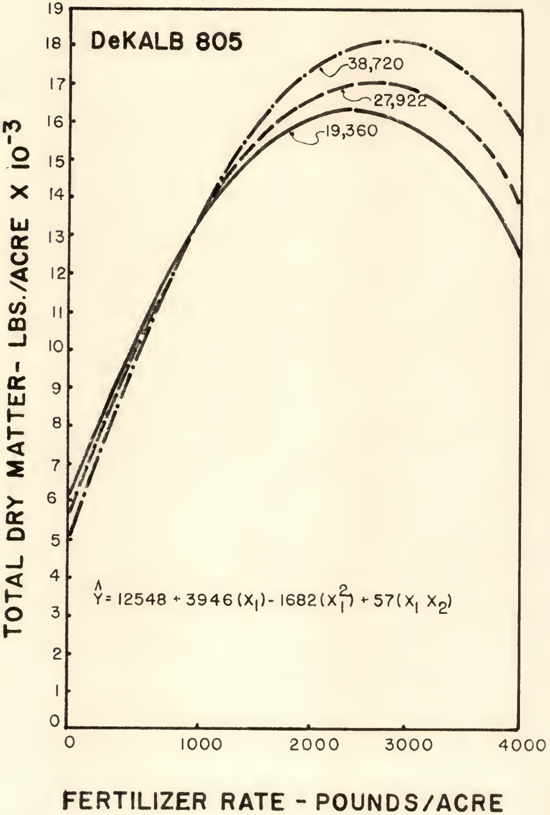

TOTAL DRY MATTER - LBS./ACRE X 10^{-3}
18
16
14
12
10
8
6
4
2
DeKALB 805
38,720
27,922
19,360
$\hat{Y} = 11680 + 4919 (X_1) + 68 (X_2) - 3534 (X_1^2)$
0
500
1000
1500
2000
FERTILIZER RATE - POUNDS / ACRE

Figure 8. Relationship between total dry matter yield and fertilizer rate (broadcast) for DeKalb 805.


DeKALB 805
38,720
27,922
19,360
$\hat{Y} = 12548 + 3946(X_1) - 1682(X_1^2) + 57(X_1 X_2)$
TOTAL DRY MATTER - LBS./ACRE X 10^{-3}
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0
1000
2000
3000
4000
FERTILIZER RATE - POUNDS/ACRE

respect to X_1 estimated the fertilizer rates (2500, 2646 and 2829 pounds per acre) at which total dry matter (16,338, 17,106 and 18,176 pounds per acre) were maximum for population rates of 19,360, 27,922 and 38,720 plants per acre) respectively. At low rates of fertility, low plant population produced slightly higher yields than the other two plant densities. However, at high fertilizer rates, 38,720 plants per acre gave more yield than did the two lower plant populations. On the other hand, Hammond and Robertson (42) observed that at low fertilization, an increase in plant population from 6590 to 23,410 plants per acre tended to produce an increase in whole plant yield.

Nutrient Uptake

In this section, a general evaluation of the nutrient content of corn will be made at first, followed by a rather detailed discussion of the effect of placement on the recovery of added fertilizer. The detailed data pertaining to the first portion of this section are presented in Tables 30, 31, 32, 33, 34, and 35 and the corresponding analysis of variance appear in Tables 23, 24, 25 and 26. Tables of analysis of variance will be discussed in relation to the three main effects, namely, fertility, plant population and hybrid.

Fertility

Fertility as a main experimental variable was highly significant for phosphorus and potassium content of corn ears, forage and total plant. Since fertility treatment had eleven degrees of freedom, eleven comparisons were made (Table 20). Nutrient uptake data for eleven comparisons are given in Tables 7 and 8. Three of the most important comparisons will be discussed in detail followed by a brief evaluation of the others.

The 3- and 6-inch broadcast treatments resulted in significantly different potassium contents of corn ears, forage and total plant and phosphorus contents in the first two plant parts. In general, more potassium was absorbed in the 6-inch treatment (Table 8) while yields of grain, forage and total dry matter were nearly the same for the 3- and 6-inch broadcast treatments (Table 5). Possibly more luxury consumption of potassium occurred where the fertilizer was incorporated to 6 inches.

There was no significant difference between the effect of 50 and 25 per cent fertilizer placement on the phosphorus and potassium content of the corn ears, forage and total plant with the exception that phosphorus uptake by forage was higher with 25 per cent placement. However, as indicated earlier, these two placement patterns had no effect on the yield of forage.

TABLE 7

Phosphorus content of corn ear, forage and total plant in relation to various fertility treatment comparisons on Leon fine sand, 1963.

Fertility treatment comparisons	Phosphorus uptake, lbs./acre		
	Corn ear	Forage	Total plant
Broadcast, 3 in.			
1000	16.29	4.86	21.14
2000	19.30	6.88	26.18
Average	17.79	5.87	23.66
Broadcast, 6 in.			
1000	15.08	5.11	20.20
2000	16.04	6.85	22.88
4000	14.09	12.65	26.74
Average	15.07	8.20	23.27
Placed 50 per cent			
500	11.36	4.12	15.49
1000	14.28	4.78	19.06
2000	15.59	6.36	21.96
Average	13.74	5.09	18.84
Placed 25 per cent			
500	9.14	5.42	14.55
1000	13.01	4.68	17.70
2000	16.50	8.13	24.63
Average	12.88	6.08	18.96
Broadcast, 3 and 6 in.	16.43	7.04	23.47
Placed 50 and 25 per cent	13.31	5.59	18.90

TABLE 8

Potassium content of corn ear, forage and total plant in relation to various fertility treatment comparisons on Leon fine sand, 1963.

Fertility treatment comparisons	Potassium uptake, lbs./acre		
	Corn ear	Forage	Total plant
Broadcast, 3 in.			
1000	23.27	65.79	89.06
2000	27.60	105.50	133.10
Average	25.44	85.65	111.08
Broadcast, 6 in.			
1000	32.14	66.77	98.91
2000	34.14	101.75	135.89
4000	29.91	152.93	182.84
Average	32.06	107.15	139.21
Placed 50 per cent			
500	23.93	46.46	70.39
1000	30.52	67.39	97.91
2000	33.66	97.72	131.38
Average	29.37	70.52	99.89
Placed 25 per cent			
500	21.41	46.75	68.15
1000	28.44	61.56	90.00
2000	34.13	106.49	140.62
Average	27.99	71.60	99.59
Broadcast 3 and 6 in.	28.75	96.40	125.15
Placed 50 and 25 per cent	28.68	71.06	99.74

Broadcast fertilizer treatment improved significantly the phosphorus uptake by corn ear, forage and total plant and potassium absorption by the last two parts to a greater extent than localized fertilizer application. Somewhat the same behavior was observed for the yields of grain, forage and total dry matter (Table 5). This indicates more efficient uptake and use of nutrients for promoting growth and improving yield with broadcast rather than localized application. However, as noted previously, differences in the nutrient contents between these two fertilizer treatments were magnified somewhat due to the fact that higher rates of fertilization were included in the broadcast treatments than in the group of placed treatments.

There were significant differences where check was compared with the remainder of the fertility treatments. Fertilizer at the rate of 200 pounds per acre incorporated at 3 inches significantly increased the phosphorus and potassium content of corn ears, forage and total plant to a greater extent than 1000 pounds per acre incorporated at the same depth. With broadcast treatments, only linear response to fertilizer rate was observed for phosphorus and potassium content of forage and total plant. It is interesting to note that neither linear nor quadratic responses were obtained for either grain yield or nutrient content of corn ears. There is evidence of luxury consumption at the high fertility rates, especially in the case of potassium. Nutrient uptake by the total plant increased linearly with the fertilizer rate, whereas the yield of total dry matter relationship was quadratic. When fertilizer was placed 25 per cent, the response was linear for the phosphorus and potassium content of corn ears, and total plant, linear for potassium uptake by forage and quadratic for phosphorus content of forage. In view of the dry matter yields (Table 22) it is logical to conclude that additional available phosphorus and potassium were used to promote vegetative growth at the expense of grain formation. With 50 per cent placement, there was a linear response for phosphorus content of corn ears, forage and total plant. In the case of potassium, the response was linear for forage and total dry matter and quadratic for corn ears. Since the response for grain, forage and total dry matter yields were also linear, this suggests that vegetative and reproductive growth were about equally influenced by these nutrients.

Plant Population

Plant population as a main effect was significant for both nutrients. The phosphorus and potassium content of corn ears were significantly greater at low than at high plant populations (Tables 9 and 10). However, for the total plants, the nutrient contents were nearly the same at the medium and high plant populations and significantly higher

TABLE 9

Phosphorus content of corn ear, forage and total plant of DeKalb 805 and Florida 200 in relation to plant population on Leon fine sand, 1963.

Hybrid	Phosphorus uptake, lbs./acre			
	1[a]	2	3	Average
		Corn ear		
DeKalb 805	15.10	14.05	13.97	14.37
Florida 200	13.16	15.08	11.01	13.08
Average	14.13	14.57	12.49	13.73
		Forage		
DeKalb 805	2.94	3.69	6.45	4.36
Florida 200	6.44	8.03	9.65	8.04
Average	4.69	5.86	8.05	6.20
		Total plant		
DeKalb 805	18.04	17.74	20.42	18.73
Florida 200	19.60	23.10	20.67	21.12
Average	18.82	20.42	20.55	19.93

[a] The plant population rates were 19,360, 27,922 and 38.720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 10

Potassium content of corn ear, forage and total plant of DeKalb 805 and Florida 200 in relation to plant population on Leon fine sand, 1963.

	Phosphorus uptake, lbs./acre			
Hybrid	1[a]	2	3	Average
		Corn ear		
DeKalb 805	35.51	36.03	33.50	35.01
Florida 200	19.16	22.02	17.28	19.49
Average	27.34	29.03	25.39	27.25
		Forage		
DeKalb 805	58.77	62.23	67.62	62.87
Florida 200	87.37	97.32	97.14	93.94
Average	73.07	79.78	82.38	78.41
		Total plant		
DeKalb 805	94.28	98.26	101.13	97.89
Florida 200	106.62	119.34	114.42	113.46
Average	100.45	108.80	107.78	105.68

[a] The plant population rates were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

than at the low population. These nutrient uptake relationships were exactly parallel to those obtained for yields of dry matter (Table 6).

Hybrid

The phosphorus and potassium content of corn ears were higher and of forage and total plant lower in DeKalb 805 than in Florida 200 (Tables 9 and 10). In both hybrids more phosphorus and less potassium was found in the corn ears than in the forage.

Although Florida 200 contained significantly higher potassium in the forage than DeKalb 805, it lodged more heavily. In general, potassium has been found to reduce lodging. Johnson (60) observed that potassium increased the strength of the corn stalk and thus ensured successful results from dressings of nitrogen. Wittels and Seatz (148) found that potash fertilization at high nitrogen rates reduced stalk breakage but had no effect at low nitrogen levels.

There was a significant interaction between plant population and hybrid in the case of phosphorus content of corn ears and total plant. This interaction was due to the fact that for DeKalb 805, the phosphorus content averaged between low and high plant populations was greater than the content at the medium population while the opposite trend was observed for Florida 200.

Fertility interacted significantly with hybrid in the case of potassium uptake by corn ears, forage and total plant. The nature of this interaction was not explored. Furthermore, in the case of potassium content of total plant, this interaction became insignificant when it was tested against its own error.

Recovery of Added Fertilizer

The uptake of fertilizer phosphorus and potassium by the total plant was estimated by subtracting the amount of these nutrients absorbed by plants growing in the check plots from that absorbed by plants in the fertilized plots. These data and the percentage recovery of phosphorus and potassium added in the fertilizer are presented in Tables 11 and 12. As the fertilization rate decreased, the percentage recovery of the two nutrients increased. The percentage recovery of phosphorus was considerably lower than that of potassium. DeKalb 805 recovered larger quantities of fertilizer phosphorus than did Florida 200 but smaller amounts of potassium.

DeWit (24) used the following equation to calculate the percentage recovery of nutrients from localized placement (R_r) as estimated from the recovery percentage of broadcast fertilizer (R_b).

$$R_r = \frac{100(X_b/X_r)^{0.56}R_b}{100+\left[(X_b/X_r)^{0.56}-1\right]R_b} \qquad (13)$$

TABLE 11

Recovery of fertilizer phosphorus by DeKalb 805 and Florida 200 with various fertility treatments on Leon fine sand, 1963.

Fertility treatment[a]	Phosphorus applied	Fertilizer phosphorus in total plant			
		DeKalb 805		Florida 200	
		Content	Recovery	Content	Recovery
	lbs./acre	lbs./acre	%	lbs./acre	%
4/100	176	18.92	10.75	17.37	9.87
2/100	88	15.30	17.39	13.27	15.08
1/100	44	12.71	28.89	10.49	23.84
2/50	88	13.63	15.49	13.08	14.86
2/100, 3 in.	88	19.48	22.14	15.69	17.83
1/50	44	10.67	24.15	10.26	23.32
1/100, 3 in.	44	14.13	32.11	10.96	24.91
0.5/50	22	8.21	37.32	5.57	25.32
2/25	88	15.38	17.49	16.68	18.95
1/25	44	9.33	21.20	8.87	20.16
0.5/25	22	6.81	30.95	5.10	23.18

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

TABLE 12

Recovery of fertilizer potassium by DeKalb 805 and Florida 200 with various fertility treatments on Leon fine sand, 1963.

Fertility treatment[a]	Potassium applied	Fertilizer potassium in total plant			
		DeKalb 805		Florida 200	
		Content	Recovery	Content	Recovery
	lbs./acre	lbs./acre	%	lbs./acre	%
4/100	500	134.99	27.00	170.91	34.18
2/100	250	100.06	40.02	111.92	44.77
1/100	125	77.14	61.71	60.89	48.71
2/50	250	88.66	35.46	114.41	45.72
2/100, 3 in.	250	99.56	39.82	106.86	42.74
1/50	125	68.34	45.14	61.90	49.52
1/100, 3 in.	125	56.43	54.67	67.70	54.16
0.5/50	63	39.88	63.81	41.11	65.78
2/25	150	102.56	41.02	118.85	47.54
1/25	125	60.50	48.40	59.73	47.78
0.5/25	63	44.29	70.86	32.24	51.58

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

where X_r and X_b are width of fertilizer band and distance between crop row, respectively. This equation is derived from the compensation function and incorporates a correction factor, $\frac{100}{100+\left[(X_b/X_r)^{0.56}-1\right]R_b}$, for the more rapid decrease in the fertilizer concentration with time in the band than in the broadcast placement. If, for purpose of illustration, $X_r/X_b = 0.50$, the correction factor will have the values of 0.96, 0.91 and 0.87 where R_b is equal to 10, 20 and 30 per cent, respectively. However, for $X_r/X_b = 0.25$, the fraction will have the values of 0.90, 0.81 and 0.74 for the same values of R_b as above. This indicates that as the recovery of broadcast fertilizer increases, the need for the correction function increases. Furthermore, for a given R_b, the correction factor is of increasing significance as X_r/X_b decreases.

In the present experiment, there were 9 fertility treatments where the recovery of phosphorus and potassium could be calculated from equation 13. These calculated percentages and the observed percentages are given in Tables 13 and 14. As the percentage recovery increased, there was a tendency for the spread between observed and calculated values to increase. At the high recoveries, the calculated values tended to be higher than the observed; the recovery of phosphorus was lower than that of potassium and the calculated and observed values were closer for phosphorus than for potassium.

TABLE 13

Observed and calculated percentage recovery of fertilizer phosphorus by DeKalb 805 and Florida 200 obtained with localized fertilizer placement on Leon fine sand, 1963.

Fertility treatment	Phosphorus added[a]	Fertilizer phosphorus recovery			
		DeKalb 805		Florida 200	
		Observed	Calculated[b]	Observed	Calculated
	ppm.	%	%	%	%
2/50	88	15.49	15.04	14.86	13.86
1/50	44	24.25	23.63	23.32	20.70
0.5/50	22	37.32	37.39	25.32	31.51
2/100, 3 in.	88	22.14	15.04	17.83	13.86
1/100, 3 in.	44	32.11	23.63	24.91	20.70
1/25	44	21.20	21.22	20.16	20.42
0.5/25	22	30.95	32.00	23.18	30.89
1/25	88	21.20	20.72	20.16	19.20
0.5/25	44	30.95	31.35	23.18	27.82

[a] Phosphorus added per unit volume of fertilized soil.

[b] Calculated with equation 13 from the percentage recovery for a broadcast treatment (except in comparisons involving placed 25 per cent vs. 50 per cent and broadcast incorporated 3 inches vs. 6 inches) which had the same amount of fertilizer per unit volume of soil as the placed treatment. $X_r/X_b = 0.50$ except in the last two treatments where $X_r/X_b = 0.25$.

TABLE 14

Observed and calculated percentage recovery of fertilizer potassium by DeKalb 805 and Florida 200 obtained with localized fertilizer placement on Leon fine sand, 1963.

Fertility treatment	Potassium added[a]	Fertilizer potassium recovery			
		DeKalb 805		Florida 200	
		Observed	Calculated[b]	Observed	Calculated
	ppm.	%	%	%	%
2/50	250	35.46	35.22	45.72	43.29
1/50	125	54.67	49.51	54.16	54.37
0.5/50	63	63.81	70.32	65.78	58.27
2/100, 3 in.	250	39.82	35.22	42.74	43.29
1/100, 3 in.	125	45.14	49.51	49.52	54.37
1/25	125	48.40	44.68	47.78	55.32
0.5/25	63	70.86	63.94	51.58	63.46
1/25	250	48.40	44.52	47.78	52.98
0.5/25	125	70.86	59.15	51.58	63.75

[a] Potassium added per unit volume of fertilized soil.

[b] Calculated with equation 13 from the percentage recovery for a broadcast (except in comparisons involving placed 25 per cent vs. 50 per cent and broadcast incorporated 3 inches vs. 6 inches) which had the same amount of fertilizer per unit volume of soil as the placed treatment $X_r/X_b = 0.50$ except in the last two treatments where $X_r/X_b = 0.25$.

The differences between observed and calculated recovery of fertilizer phosphorus were higher with Florida 200 than DeKalb 805. In the case of potassium this trend was reversed, namely, for DeKalb 805 the differences were more than those for Florida 200. The variations between observed and calculated values of phosphorus recovery were wider for 2000 and 1000 pounds of fertilizer per acre incorporated at 3 inches than for the rest of fertilizer treatments. For potassium the differences between observed and calculated recoveries were nearly the same for every fertilizer treatment.

The theoretical ratios between U_r (nutrient uptake from placed fertilizer) and U_b (yield of nutrient from broadcast fertilizer) calculated from the DeWit compensation function

$$U_r/U_b = (X_r/X_b)^{0.44} \tag{14}$$

were 0.75 and 0.54 for the placement ratios of 0.50 and 0.25, respectively. These latter values were called compensation factors by DeWit. This equation applies when the concentrations of fertilizer in the band and broadcast patterns are the same. In the present study nine treatment comparisons met this requirement and the observed U_r/U_b values in each case for phosphorus and potassium are given in Tables 15, 16, 17 and 18. It is interesting to note that for phosphorus the differences between the observed values of

TABLE 15

Recovery of fertilizer phosphorus by DeKalb 805 and observed and calculated values of U_r/U_b.

Fertility treatment		Phosphorus added[a]	Yield of fertilizer phosphorus in total plant		U_r/U_b[b]	
Localized placement	Broadcast placement		Localized placement	Broadcast placement	Observed	Calculated
		ppm.	lbs./acre	lbs./acre		
2/50	4/100	88	13.63	18.92	0.72	0.70
1/50	2/100	44	10.67	15.30	0.70	0.68
0.5/50	1/100	22	8.21	12.71	0.64	0.65
2/100, 3 in.	4/100	88	19.48	18.92	1.03	0.70
1/100, 3 in.	2/100	44	14.13	15.30	0.92	0.68
1/25	2/50	44	9.33	13.63	0.68	0.68
0.5/25	1/50	22	6.81	10.67	0.64	0.66
1/25	4/100	88	9.33	18.92	0.49	0.48
0.5/25	2/100	44	6.81	15.30	0.44	0.45

[a] Phosphorus added per unit volume of fertilized soil.

[b] Note that the two treatments involved include placed vs. broadcast, placed 25 per cent vs. 50 per cent and broadcast incorporated 3 inches vs. 6 inches. Equation 15 was used for the calculated values where $X_r/X_b = 0.50$ in all comparisons except the last two where $X_r/X_b = 0.25$.

TABLE 16

Recovery of fertilizer phosphorus by Florida 200 and observed and calculated values of U_r/U_b.

Fertility treatment			Yield of fertilizer phosphorus in total plant		U_r/U_b [b]	
Localized placement	Broadcast placement	Phosphorus added[a]	Localized placement	Broadcast placement	Observed	Calculated
		ppm.	lbs./acre	lbs./acre		
2/50	4/100	88	13.08	17.27	0.75	0.70
1/50	2/100	44	10.26	13.27	0.77	0.69
0.5/50	1/100	22	5.57	10.49	0.53	0.66
2/100, 3 in.	4/100	88	15.69	17.37	0.90	0.70
1/100, 3 in.	2/100	88	10.96	13.27	0.82	0.69
1/25	2/50	44	8.87	13.08	0.68	0.69
0.5/25	1/50	22	5.10	10.26	0.50	0.66
1/25	4/100	88	8.87	17.37	0.51	0.49
0.5/25	2/100	44	5.10	13.27	0.38	0.46

[a] Phosphorus added per unit volume of fertilized soil.

[b] Note that the two treatments involved include placed vs. broadcast, placed 25 per cent vs. 50 per cent and broadcast incorporated 3 inches vs. 6 inches. Equation 15 was used for the calculated values where $X_r/X_b = 0.50$ in all comparisons except the last two where $X_r/X_b = 0.25$.

TABLE 17

Recovery of fertilizer potassium by DeKalb 805 and observed and calculated values of U_r/U_b.

Fertility treatment		Potassium added[a]	Yield of fertilizer potassium in total plant		U_r/U_b [b]	
Localized placement	Broadcast placement		Localized placement	Broadcast placement	Observed	Calculated
		ppm.	lbs./acre	lbs./acre		
2/50	4/100	250	88.66	134.99	0.66	0.65
1/50	2/100	125	68.34	100.06	0.68	0.62
0.5/50	1/100	63	39.88	77.14	0.52	0.57
2/100, 3 in.	4/100	250	99.56	134.99	0.74	0.65
1/100, 3 in.	2/100	125	56.43	100.06	0.56	0.62
1/25	2/50	125	60.50	88.60	0.68	0.63
0.5/25	1/50	63	44.29	68.34	0.65	0.58
1/25	4/100	250	60.50	134.99	0.45	0.41
0.5/25	2/100	125	44.29	100.06	0.44	0.37

[a] Potassium added per unit volume of fertilized soil.

[b] Note that the two treatments involved include placed vs. broadcast, placed 25 per cent vs. 50 per cent and broadcast incorporated 3 inches vs. 6 inches. Equation 15 was used for the calculated values where $X_r/X_b = 0.50$ in all comparisons except the last two where $X_r/X_b = 0.25$.

TABLE 18

Recovery of fertilizer potassium by Florida 200 and observed and calculated values of U_r/U_b.

Fertility treatment		Potassium added[a]	Yield of fertilizer potassium in total plant		U_r/U_b [b]	
Localized placement	Broadcast placement		Localized placement	Broadcast placement	Observed	Calculated
		ppm.	lbs./acre	lbs./acre		
2/50	4/100	250	114.31	170.91	0.67	0.63
1/50	2/100	125	67.70	111.92	0.60	0.61
0.5/50	1/100	63	41.11	60.89	0.67	0.60
2/100, 3 in.	4/100	250	106.86	170.91	0.62	0.63
1/100, 3 in.	2/100	125	61.90	111.92	0.55	0.61
1/25	2/50	125	59.73	114.31	0.52	0.60
0.5/25	1/50	63	32.24	67.70	0.48	0.58
1/25	4/100	250	59.73	170.91	0.35	0.39
0.5/25	2/100	125	32.24	111.92	0.29	0.35

[a] Potassium added per unit volume of fertilized soil.

[b] Note that the two treatments involved include placed vs. broadcast, placed 25 per cent vs. 50 per cent broadcast incorporated 3 inches vs. 6 inches. Equation 15 was used for the calculated values where $X_r/X_b = 0.50$ in all comparisons except the last two where $X_r/X_b = 0.25$.

U_r/U_b and the theoretical values of 0.75 and 0.54 were smaller than those for potassium. The observed U_r/U_b values were lowest for potassium in most cases. This was undoubtedly due to two reasons. First, the percentage recovery of fertilizer phosphorus was lower than that of potassium (Tables 11 and 12). This is an important consideration in the use of the compensation function, because DeWit (24) stated that the compensation function could be used to calculate U_r from U_b under conditions where the recovery of placed fertilizer did not exceed 30 per cent. Second, it would be expected that the reaction of phosphorus with the soil would tend to keep this nutrient within the volume of soil in which it was placed. This likewise is an important consideration in using the compensation function.

The importance of the recovery percentage in affecting the observed U_r/U_b values can also be seen in the increasing values of U_r/U_b with increasing rates of fertilization (recovery percentage decreasing). Singh and Black (124), in a greenhouse study with phosphorus, noted a consistent tendency for the observed values of U_r/U_b to increase with an increase in applied fertilizer phosphorus. They stated that this might result from a more rapid rate of decrease of fertilizer (more intense plant uptake) in the band than in the broadcast pattern - a difference which would be more marked at lower rates of fertilizer.

The observed U_r/U_b values for the two hybrids differed materially. For Florida 200 the range of values from high to low was greater than for DeKalb 805, especially if one excludes the comparison involving depth of fertilizer placement. The tendency for the Florida 200 data to be more variable was noted in material already presented.

In the comparison between broadcast fertilizer incorporated 3 inches versus 6 inches, observed U_r/U_b values were larger than the theoretical value of 0.75 for the two hybrids, in the case of phosphorus. With potassium, the observed U_r/U_b values were lower than 0.75. It is not clear why such behavior was observed in the present study.

It is not logical to expect the observed U_r/U_b values to be as high as the theoretical 0.75 and 0.54 in view of the relatively high recovery percentages obtained. The DeWit compensation function was derived with the assumption that the decrease in fertilizer concentration with time would be the same in the band as in the broadcast pattern. Obviously this did not hold in the present experiment. The discrepancy between the fertilizer concentration in the band and broadcast treatments became greater as the recovery of fertilizer increased. Calculation of U_r/U_b values on the basis of high recovery percentages can be made from equation 13 which includes DeWit's correction factor or from the following equation derived from equation 13.

$$U_r/U_b = \frac{(X_r/X_b)^{0.44}}{1 + \left[(X_b/X_r)^{0.56} - 1\right]\frac{U_b}{M_b}} \qquad (15)^{1}$$

The notations are the same as previously given, except that M_b represents the amount of nutrient broadcast. The U_r/U_b values calculated from U_b/M_b data and this equation are also included in Tables 15, 16, 17 and 18.

In general, there was a remarkable agreement between observed and calculated U_r/U_b values. In the case of phosphorus, the difference between observed and calculated values of U_r/U_b was significant at 5 per cent level of probability only where broadcast incorporated 3 inches was compared with 6 inches. The spread between observed and calculated U_r/U_b values for phosphorus was smaller for DeKalb 805 than Florida 200. For potassium, this difference between hybrids was not so marked.

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[1] Equation 13 slightly rearranged and multiplied by X_r/X_b is

$$R_r/R_b(X_r/X_b) = \frac{100(X_r/X_b)^{0.44}}{100 + \left[(X_b/X_r)^{0.56} - 1\right]R_b}$$

since $(X_r/X_b)(X_b/X_r)^{0.56} = (X_r/X_b)^{0.44}$. Substituting for R_r and R_b from the relationships $R_r = \frac{U_r 100}{M_b(X_r/X_b)}$ and $R_b = \frac{U_b 100}{M_b}$ one obtains

$$U_r/U_b = \frac{(X_r/X_b)^{0.44}}{1 + \left[(X_b/X_r)^{0.56} - 1\right]\frac{U_b}{M_b}}$$

which is equation 15.

In order to investigate the compensation function further, observed U_r/U_b values for phosphorus and potassium, averaged over population and hybrid, were plotted in Figures 10 and 11. The compensation function is represented by a solid line while the broken lines are 95.8 per cent confidence intervals calculated by DeWit. It is evident that for $X_r/X_b = 0.50$, the observed values for potassium do not fit the theory as well as for phosphorus. Furthermore, the fit of observed values for phosphorus and potassium was generally poorer than the fit of the data originally used by DeWit (Figure 9) to evaluate the compensation function. Singh and Black (124) observed that uptake of placed phosphorus relative to that of broadcast differed significantly among phosphorus and water levels. However, the deviations were in the same order of magnitude as those found by DeWit.

Because of relatively high fertilizer recovery in this experiment even in the case of phosphorus, the most proper comparison is between the observed and calculated values of U_r/U_b as previously presented (Tables 15, 16, 17 and 18). However, one may also compare the theoretical values of 0.75 and 0.54 with observed values of U_r/U_b adjusted with DeWit's correction factor. The adjusted observed values shown in Table 19 were obtained by dividing the observed values by $\dfrac{1}{1+\left[(X_b/X_r)^{0.56}-1\right]\dfrac{U_b}{M_b}}$, which

Figure 9. Relationship between U_r/U_b and X_r/X_b; data of DeWit. The solid line represents the compensation function and the broken lines the 95.8 per cent confidence interval calculated by DeWit.

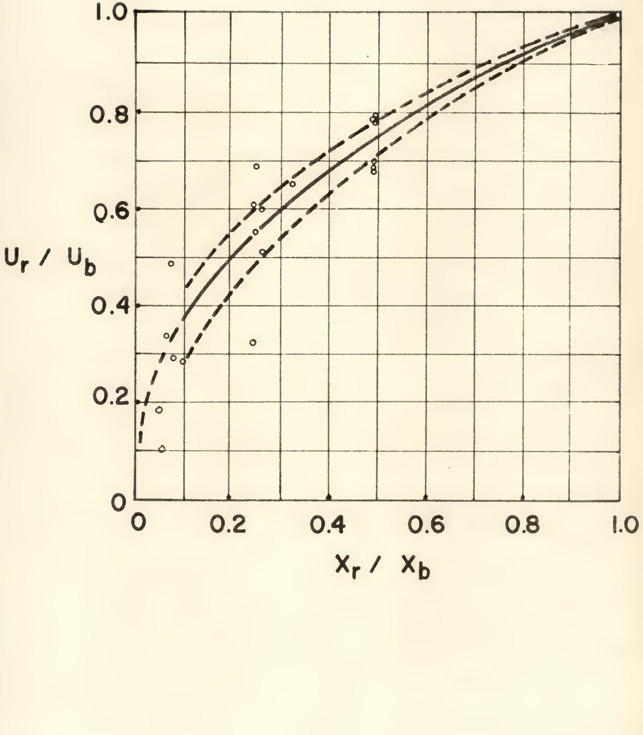
1.0
0.8
0.6
0.4
0.2
0
U_r / U_b
0
0.2
0.4
0.6
0.8
1.0
X_r / X_b

Figure 10. Relationship between U_r/U_b and X_r/X_b for phosphorus. Solid and broken lines same as in Figure 9.

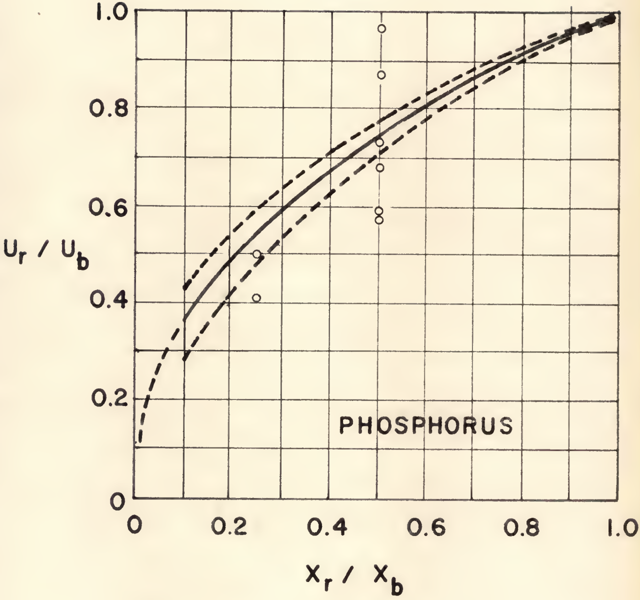
1.0
0.8
0.6
0.4
0.2
0
U_r / U_b
0
0.2
0.4
0.6
0.8
1.0
X_r / X_b
PHOSPHORUS

Figure 11. Relationship between U_r/U_b and X_r/X_b for potassium. Solid and broken lines same as in Figure 9.

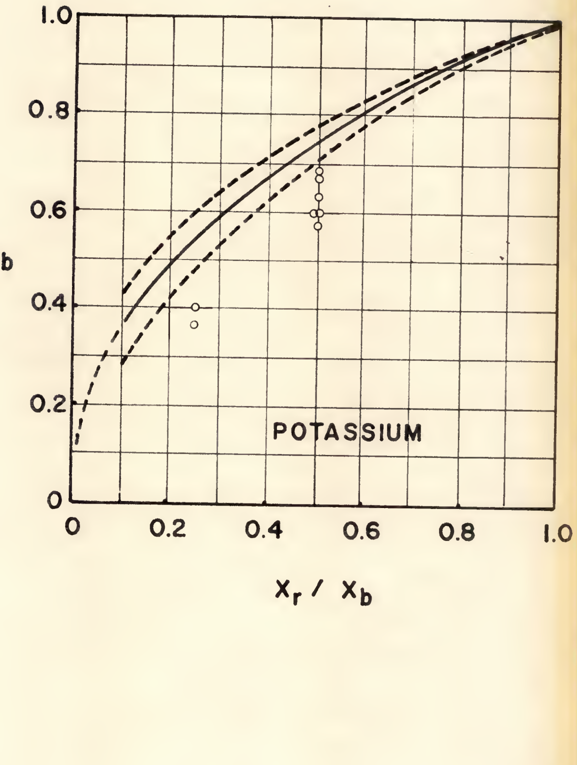
1.0
0.8
0.6
0.4
0.2
0
U_r / U_b
POTASSIUM
0
0.2
0.4
0.6
0.8
1.0
X_r / X_b

TABLE 19

Theoretical and adjusted observed U_r/U_b values in relation to fertilizer rate and placement pattern.

Fertility treatment		U_r/U_b		
Localized placement	Broadcast placement	Adjusted Phosphorus	 Potassium	Theoretical
2/50	4/100	0.77	0.78	0.75
1/50	2/100	0.81	0.78	0.75
0.5/50	1/100	0.67	0.76	0.75
2/100, 3 in.	4/100	1.04	0.80	0.75
1/100, 3 in.	2/100	0.95	0.68	0.75
1/25	2/50	0.75	0.73	0.75
0.5/25	1/50	0.65	0.73	0.75
1/25	4/100	0.56	0.54	0.54
0.5/25	2/100	0.49	0.55	0.54

is DeWit's correction factor included in equation 15. There was only one case for potassium and three cases for phosphorus where these adjusted U_r/U_b values (calculated for combined hybrids) failed to come within the confidence interval calculated by DeWit.

Thus, whether the comparison was made between observed and calculated U_r/U_b values, or between DeWit's confidence intervals and observed U_r/U_b values adjusted for high recovery, the result was a reasonably good agreement between theory and actual field data.

SUMMARY AND CONCLUSIONS

An investigation was made of the effect of fertilizer rate and placement pattern and plant population on the yield and nutrient uptake of two corn hybrids grown on Leon fine sand with water tables controlled at 18- and 30-inch depths. The experimental design was a randomized block with 72 treatments in a factorial arrangement. The treatments consisted of 12 fertility combinations using different rates of broadcast and band applied fertilizer, 3 plant populations and 2 hybrids. The maintenance program consisted of side-dressing the corn with ammonium nitrate to give the equivalent of a 15-10-15 (N-P_2O_5-K_2O) fertilizer grade, application of DDT for budworm control and use of atrazine for weed eradication. Precipitation was the only weather measurement made at the experimental site. The main criteria of response were yields of grain, forage and total dry matter and phosphorus and potassium uptake by corn ears, forage and total plant. These responses were evaluated statistically by making combined analyses of variance on the two water tables. Furthermore, a more detailed study of grain, forage and total dry matter yields was made by regression analyses.

Soil analysis after termination of the experiment showed that soil pH and the amounts of phosphorus, potassium, calcium and magnesium decreased with depth. In general, calcium tended to reach only into the 6- to 12-inch soil layer while potassium and magnesium moved through the profile to depths of 12 to 18 inches.

Fertility, plant population and hybrid as main experimental variables significantly affected yield and nutrient uptake. Several comparisons within the fertility variable were of interest. In general, yields of grain, forage and total dry matter were nearly the same with 3-inch as with 6-inch incorporation of broadcast fertilizer. However, more potassium was absorbed in the 6-inch than the 3-inch treatment. This indicates the possibility of luxury consumption of potassium in the case of broadcast fertilizer incorporated 6 inches. There was no significant difference between the effect of 50 and 25 per cent fertilizer placement either on yields of dry matter or nutrient uptake with the exception that phosphorus uptake by forage was higher with fertilizing 25 per cent of the area. Yields of dry matter and nutrient uptake were both improved to a greater extent by broadcasting the fertilizer than by placing it in bands.

When three rates of fertilizer (500, 1000 and 2000 pounds per acre) were placed in one-fourth of the area, the response was quadratic for grain and linear for forage and total dry matter. For nutrient uptake, linear responses were observed in all cases except for the phosphorus content of forage where the response was quadratic. In view of the linear response obtained for the yield of dry matter and the quadratic response for grain yields, it is logical to conclude that the additional amounts of phosphorus and potassium absorbed by the plant as fertilizer rate increased were used to promote vegetative growth at the expense of grain formation.

Where fertilizer (500, 1000 and 2000 pounds per acre) was placed in one-half the area the response was linear for both yield of dry matter and nutrient uptake. Vegetative and reproductive growth were about equally influenced by the nutrients.

The response to broadcast fertilizer (1000, 2000 and 4000 pounds per acre) was neither linear nor quadratic for either grain or nutrient content of corn ears. However response was quadratic for yields of forage and total dry matter and linear for phosphorus and potassium content of forage and total plant. This indicates that luxury consumption of nutrients occurred, at least at the 2000 and 4000 pounds per acre rates.

The nutrient uptake-plant population relationships were parallel to the yield-plant population relationships for grain, forage and total dry matter. The grain response (yield and nutrient content) increased up to medium plant >

population and decreased thereafter, while forage and total dry matter responses (yield and nutrient content) increased with plant population.

The overall average grain production of DeKalb 805 was higher than that of Florida 200. However, the latter hybrid produced more forage and total dry matter than the former hybrid. Furthermore, the phosphorus and potassium content of corn ears were higher and of forage and total plant lower in DeKalb 805 than Florida 200. There was a significant interaction between fertility and hybrid for yields of grain and forage. However this interaction was insignificant when tested against its own error. Moreover, hybrid interacted significantly with plant population for phosphorus uptake and with fertility for potassium uptake.

The regression analyses provided twelve yield response equations (2 hybrids, 3 plant parts, 2 fertilizer placement patterns-broadcast and banded). These equations were useful in finding approximate maxima of response to fertilizer rate and plant population and in further evaluating hybrid and fertilizer placement effects.

Evaluation of data pertaining to the recovery of added fertilizer showed that as fertilizer rate increased, the recoveries of phosphorus and potassium in total plant of the two hybrids decreased. DeKalb 805 recovered larger quantities of fertilizer phosphorus and smaller amounts of fertilizer potassium than Florida 200.

The differences between DeWit's theoretical ratios of uptake from placed fertilizer to uptake from broadcast fertilizer ($U_r/U_b = 0.75$ and 0.54 for $X_r/X_b = 0.50$ and 0.25) and observed U_r/U_b values were smaller for phosphorus than potassium. However, in most cases, observed values of U_r/U_b for both phosphorus and potassium failed to come within the confidence interval calculated by DeWit. As fertilizer rate increased and the recovery rate decreased, there was a consistent tendency for the observed U_r/U_b values to increase. When the ratios were calculated for broadcast incorporated 3 inches versus 6 inches, average observed values of U_r/U_b were 0.92 for phosphorus and 0.62 for potassium.

The failure of DeWit's compensation function to predict the observed U_r/U_b values was expected because of the relatively high recovery of applied fertilizer. A correction of the compensation function for high recovery was made with the equation

$$U_r/U_b = \frac{(X_r/X_b)^{0.44}}{1+\left[(X_b/X_r)^{0.56}-1\right]\frac{U_b}{M_b}}$$

The calculated U_r/U_b values obtained in this way were not significantly different from the observed values with one exception. This was for phosphorus uptake from fertilizer broadcast and incorporated to a depth of 3 inches compared to broadcast fertilizer incorporated to a depth of 6 inches.

When comparison was made between theoretical values of 0.75 and 0.54 and observed U_r/U_b values adjusted by dividing by DeWit's correction factor, $\frac{1}{1+\left[(X_b/X_r)^{0.56}-1\right]\frac{U_b}{M_b}}$, there was only one case out of 9 for potassium and three cases out of 9 for phosphorus where these adjusted U_r/U_b values failed to come within the confidence interval calculated by DeWit. Thus whether a comparison was made between observed and calculated U_r/U_b values or between DeWit's confidence intervals and observed U_r/U_b values adjusted for high recovery, the result was a reasonably good agreement between theory and actual field data.

In conclusion, the results of this one-year experiment may be interpreted as follows:

1. It seems that at low rates (1000 pounds per acre), broadcasting of fertilizer was more effective than band placement in increasing yields of grain and total dry matter. At higher rates of fertilization (2000 pounds per acre) localized placement of fertilizer increased grain production to a greater extent than broadcast application, while total dry matter yields were about the same for both treatments. Similar studies should be conducted with other crops and hybrids in other locations with different environmental conditions.

2. If corn is grown for forage or silage, use of fertilizer rates and plant populations higher than those generally used for grain production may be justified. In

the present experiment, maximum grain yields were predicted at a broadcast fertilizer rate of 2500 pounds per acre (15-10-15, $N-P_2O_5-K_2O$), while maximum total dry matter yields were predicted at approximately 2700 pounds per acre.

3. In the selection of hybrids, the purpose for which the crop is grown should be considered. The early, short stalk hybrid, DeKalb 805, was best for grain production, whereas the late, long stalk hybrid, Florida 200, was best for forage production. The unexpected good grain yields at the high plant populations in this experiment suggest that selection and breeding of maize for high plant densities and high fertilization levels would be advisable.

4. The DeWit theory on fertilizer placement appears to be useful as a first approximation in predicting the relationships between absorption of fertilizer from band and from broadcast applications only where a correction is made for the effect of high nutrient recovery. However, DeWit's compensation function *per se* is not only inapplicable in predicting nutrient uptake for localized placement from that of broadcast placement in the present study, but also is not helpful in advising on the placement pattern of fertilizer for maximum yield production on sandy soils low in fertility.

LITERATURE CITED.

1. Andharia, R. M., Stanford, G., and Schaller, F. G. Nitrogen status of Marshall silt loam as influenced by different crop rotations. Soil Sci. Soc. Am. Proc. 17: 247-251, 1953.

2. Bartholomew, R. P. Increasing corn yields in Arkansas. Arkansas Agr. Exp. Sta. Bull. 473, 1948.

3. Bear, F. E. Principles of fertilizer application. Proc. 17th Ann. Meet. Natl. Joint Comm. on Fert. Appl.: 29-31, 1941.

4. Bennett, W. F., Stanford, G., and Dumenil, L. Nitrogen phosphorus and potassium content of the corn leaf and grain as related to nitrogen fertilization and yields. Soil Sci. Soc. Am. Proc. 17: 252-258, 1953.

5. Blaser, R. E., and McAuliffe, C. Utilization of phosphorus from various fertilizer materials: I. Orchard grass and Ladino clover in New York. Soil Sci. 68: 145-150, 1949.

6. Bowers, J. L. The effect of spacing and number of plants per hill on the yield of eleven sweet corn hybrids. Proc. Am. Soc. Hort. Sci. 43: 275-277, 1943.

7. Breland, H. L. Methods of analysis used in soil testing. Florida Agr. Exp. Sta., Dept. of Soils Mimeo Report No. 58-3, 1957.

8. Brensing, O. H., and Harper, H. J. Nitrogen fertilization of corn with supplemental irrigation; cooperative trials at five locations in central and eastern Oklahoma. Oklahoma Agr. Exp. Sta. Bull. B-557, 1960.

9. Briggs, L. F., and Shantz, H. L. The water requirement of plants: II. A review of the literature. USDA Bur. plant Ind. Bull. 285, 1913.

10. Bushnell, J. Symptoms of fertilizer injury to potatoes. Jour. Am. Soc. Agron. 25: 397-407, 1933.

11. Chandler, W. V. Nutrient uptake by corn in North Carolina. North Carolina Agr. Exp. Sta. Tech. Bull. 143, 1960.

12. Chapman, H. D., and Pratt, P. F. Methods of Analysis For Soils, Plants and Waters. Univ. of Calif. Division of Agr. Sci., 1961.

13. Chapman, W. H. Grain crop investigations. Florida Agr. Exp. Sta. Ann. Rept. 214, 1950.

14. ____________. The effects of spacing, hybrids and varieties, fumigation and mulches on yields of highly fertilized corn. Soil and Crop. Sci. Soc. Fla. Proc. 21: 206-213, 1961.

15. Coe, D. G. The effects of various methods of applying fertilizers on crop yields. Soil Sci. 21: 127-141, 1926.

16. Colville, W. L., and McGill, D. P. Effect of rate and method of planting in several plant characters and yield of irrigated corn. Agron. Jour. 54: 235-238, 1962.

17. Cooke, G. W. Placement of fertilizers for row crops. Jour. Agr. Sci. 39: 359-373, 1949.

18. __________. Recent advances in fertilizer placement: II. Fertilizer placement in England. Jour. Sci. Food Agr. 5: 429-440, 1954.

19. Cummings, R. W. Principles determining where fertilizer should be placed for greatest efficiency. Proc. 19th Ann. Meet. Natl. Joint Comm. on Fert. Appl. 27-32, 1943.

20. Datta, N. P., Baines, S. S., and Relwani, L. L. Fertilizer experiment on maize: I. Direct effect of nitrogenous phosphatic and potassic fertilizers and their combination on yield. Indian Jour. Agr. Sci. 29: 22-34, 1959.

21. Davide, J. G. The effects of fertilizer and population density on the growth and yield of corn in the Philippines. Philippine Agr. 45: 573-586, 1962.

22. Davis. F. E., and Pallesen, J. E. Effect of the amount and distribution of rainfall and evaporation during the growing season on the yield of corn and spring wheat. Jour. Agr. Res. 60: 1-23, 1940.

23. Denmead, O. T., and Shaw, R. H. The effect of soil moisture stress at different stages of growth on the development and yield of corn. Agron. Jour. 52: 272-274, 1960.

24. DeWit, C. T. A physical theory on placement of fertilizers. Versl. Landbouwk Onderz. No. 59.4, 1953.

25. Diamond, R. B., Hammond, L. C., and Myers, J. M. Drainage characteristics of Leon and Felda sands. I. Water table behavior. Soil and Crop Sci. Soc. Fla. Proc. 21: 28-44, 1961.

26. Duley, F. L. Methods of applying fertilizers to wheat. Jour. Am. Soc. Agron. 22: 515-521, 1930.

27. Duncan, E. R. Influences of varying plant population, soil fertility and hybrid on corn yields. Soil Sci. Soc. Am. Proc. 18: 437-440, 1954.

28. Dungan, G. H., Lang, A. L., and Pendleton, J. W. Corn plant population in relation to soil productivity. Advances in Agron. 10: 469, 1958.

29. Eck, H. V., and Fanning, C. Placement of fertilizer in relation to soil moisture supply. Agron. Jour. 53: 335-338, 1961.

30. Enyi, B. A. C. The effect of seedling age, depth of planting and fertilizer placement on the growth and yield of rice (Oryza sativa L.). Jour. Agr. Sci. 61: 291-197, 1963.

31✓ Fisher, F. L., and Smith, O. E. Influence of nutrient balance on yield and lodging of Texas hybrid corn. No. 28. Agron. Jour. 52: 201-204, 1960.

32. Fiskell, J. G. A. Corn yields and incidence of barren stalks in an experiment using high nitrogen rates - a progress report. Soil and Crop Sci. Soc. Fla. Proc. 21: 237-244, 1961.

33. Forsee, W. T., Jr., Green, V. E., Jr., and Webster, R. H. Fertilizer experiments with field corn on Everglades peaty muck soil. Soil Sci. Soc. Am. Proc. 18: 76-79, 1954.

34. ________________. Current status and future development of research pertaining to the nutrient requirements of field crops growing on the organic and sandy soils of southern Florida. Soil and Crop Sci. Soc. Fla. Proc. 20: 316-323, 1960.

35. Fulton, J. M., and Findlay, W. I. The nutrient composition of hybrid corn as influenced by fertilization: I. The nitrogen percentage in leaf and grain. Canad. Jour. Soil Sci. 40: 42-48, 1960.

36. Gammon, N., Jr., Bullock, R. J., and Neller, J. R. Changes in pasture fertilization. Soil and Crop Sci. Soc. Fla. Proc. 19: 166-172, 1959.

37. Gard, L. E., McKibben, G. E., and Jones, B. A., Jr. Moisture loss and corn yields on a silt-pan soil as affected by three levels of water supply. Soil Sci. Soc. Am. Proc. 25: 154-157, 1961.

38. Greaves, J. E., and Nelson, D. H. The influence of irrigation water and manure on the composition of the corn kernel. Jour. Agr. Res. 31: 183-189, 1925.

39. Grunes, D. L., Viets, F. G., Jr., and Shih, S. H. Proportionate uptake of soil and fertilizer phosphorus by plants as affected by nitrogen fertilization: I. Growth chamber experiment. Soil Sci. Soc. Am. Proc. 22: 43-48, 1958.

40. Haddock, J. L. The influence of soil moisture condition on the uptake of phosphorus from calcareous soils by sugarbeets. Soil Sci. Soc. Am. Proc. 16: 235-238, 1952.

41. Hall, N. S., Chandler, W. F., Van Bavel, C. H. M., Reid, P. H., and Anderson, J. H. A tracer technique to measure the growth and activity of plant root systems. North Carolina Agr. Exp. Sta. Tech. Bull. 101, 1953.

42. Hammond, L. C., and Robertson, W. K. The effect of plant population and fertilization rate on yield and nutrient uptake of corn on flatwoods soils. Soil and Crop Sci. Soc. Fla. Proc. 23: 74-81, 1963.

43. Hanks, R. J., and Tanner, C. B. Water consumption by plants as influenced by soil fertility. Agron. Jour. 44: 98-100, 1952.

44. Harshbarger, K. E., Nevens, W. B., Touchberry, R. W., Lang, A. L., and Dungan, G. H. Yield and composition of corn forage as influenced by soil fertilization. Illinois Agr. Exp. Sta. Bull. 577, 1954.

45. Horner, E. S., and Hull, F. H. Corn improvement. Florida Agr. Exp. Sta. Ann. Rept. 55, 1952.

46. ______________., McCloud, D. E., and Wofford, I. M. Plant population and nitrogen fertilization for field corn in North Florida. Soil and Crop Sci. Soc. Fla. Proc. 19: 197-208, 1959.

47. ______________. Response of corn hybrids to dense planting and high fertilization. Soil and Crop Sci. Soc. Fla. Proc. 21: 245-247, 1961.

48. Howe, O. W., and Rhoades, H. F. Irrigation practice for corn production in relation to stage of plant development. Soil Sci. Soc. Am. Proc. 19: 94-98, 1955.

49. Huelsen, W. A. Yield of sweet corn in relation to distance and rate of planting. Illinois Agr. Exp. Sta. Bull. 487, 1942.

50. Hunter, A. S., and Yunger, J. A. The influence of variations in fertility levels upon the yield and protein content of field corn in eastern Oregon. Soil Sci. Soc. Am. Proc. 19: 214-218, 1955.

51. Hutton, C. E., Lundy, H. W., and Robertson, W. K. Managing west Florida soils for high corn yields. Florida Agr. Exp. Sta. Circ. S-76, 1954.

52. __________., Lutrick, M. C., and Robertson, W. K. Limiting factors in field crop production in northwestern Florida. Soil and Crop Sci. Soc. Fla. Proc. 20: 298-306, 1960.

53. Jackson, M. L. Soil Chemical Analysis. Prentice-Hall, Inc. Englewood Cliffs, N. J. Pp. 148-151, 461-464, 1962.

54. Jacob, K. D., and Hill, W. L. Laboratory evaluation of phosphate fertilizers. *In* W. H. Pierre and A. G. Norman, ed. Soil and Fertilizer Phosphorus. Academic Press, Inc., New York. Pp. 299-340, 1953.

55. Jenne, E. A., Rhoades, H. F., Yien, C. H., and Howe, O. W. Change in nutrient element accumulation by corn with depletion of soil moisture. Agron. Jour. 50: 71-74, 1958.

56. Jenny, H. A. Study of the influence of climate upon the nitrogen and organic matter content of the soil. Missouri Agr. Exp. Sta. Res. Bull. 152, 1930.

57. Jensen, D., and Pesek, J. Inefficiency of fertilizer use resulting from nonuniform spatial distribution: I. Theory. Soil Sci. Soc. Am. Proc. 26: 170-173, 1962.

58. __________ and __________. Inefficiency of fertilizer use resulting from nonuniform spatial distribution: II. Yield losses under selected distribution patterns. Soil. Sci. Soc. Am. Proc. 26: 174-178, 1962.

59. __________ and __________. Inefficiency of fertilizer use resulting from nonuniform spatial distribution: III. Fractional segregation in fertilizer materials. Soil Sci. Soc. Am. Proc. 26: 178-182, 1962.

60. Johnson, P. E. Potassium-nitrogen balance for high corn yields. Better Crops and Plant Food. 36: 6-12, 47-50, 1952.

61. Jones, W. J., and Houston, H. A. Composition of maize at various stages of its growth. Indiana Agr. Exp. Sta. Bull. 175, 1914.

✓62. Jordan, H. V., Laird, K. D., and Ferguson, D. D. Growth rates and nutrient uptake by corn in a fertilizer-spacing experiment. Agron. Jour. 42: 261-268, 1950.

63. Kelley, O. J. Requirement and availability of soil water. Advances in Agron. 6: 67-94, 1954.

64. Kiesselbach, T. A. Transpiration as a factor in crop production. Nebraska Agr. Exp. Sta. Res. Bull. 6, 1916.

65. ________________. Progressive development and seasonal variations of the corn crop. Nebraska Agr. Exp. Sta. Res. Bull. 166, 1950.

66. Knipmeyer, J. W., Hageman, R. H., Earley, E. B., and Seif, R. D. Effect of light intensity on certain metabolites of the corn plant (Zea mays L.). Crop Sci. 2: 1-5, 1962.

67. Koger, M., Blue, W. G., Killinger, G. B., Greene, R. E. L., Harris, H. C., Myers, J. M., Warnick, A. C., and Gammon, N., Jr. Beef production, soil and forage analyses, and economic returns from eight pasture programs in North Central Florida. Florida Agr. Exp. Sta. Bull. 631, 1961.

✓68. Krantz, B. A., and Chandler, W. V. Lodging, leaf composition and yield of corn as influenced by heavy applications of nitrogen and potash. Agron. Jour. 43: 547-552, 1951.

✓69. __________ and ________________. Fertilizer corn for higher yields. North Carolina Agr. Exp. Sta. Bull. 366, 1954.

70. Larson, C. A., Viets, F. G., and Leamer, R. W. Field corn production on the Umatilla Irrigation Project. Oregon Agr. Exp. Sta. Bull. 480, 1950.

71. Lawton, K. Fertilizer coatings: The effect of coatings on the dissolution of fertilizers and the uptake of fertilizer potassium by plants. Agr. and Food Chem. 9: 276-280, 1961.

72. ________. Coated fertilizers in the future. Better Crops with Plant Food. 45: 18, 1961.

73. Letey, J., and Peters, D. B. Influence of soil moisture levels and seasonal weather on efficiency of water use by corn. Agron. Jour. 49: 362-365, 1957.

74. Lewis, A. H. The placement of fertilizers: I. Root crops. Jour. Agr. Sci. 31: 295-307, 1941.

75. ________, and Strickland, A. G. The placement of fertilizers: II. Cereals. Jour. Agr. Sci. 34: 73-75, 1944.

76. Long, O. H. Nitrogen and spacing experiments with corn. Tennessee Agr. Exp. Sta. Bull. 232: 34, 1953.

77. Loué, A. Maize nutrition-cation requirements and potash demands. World Crops. 15: 373-379, 1963.

78. Luetkemeier, O. W., and Kohnke, H. The influence of supplemental irrigation on corn yields in Indiana. Soil Sci. Soc. Am. Proc. 14: 379-383, 1949.

79. McCalla, A. G., and Woodford, E. K. Effects of a limiting element on the absorption of individual elements and on the anion: cation balance in wheat. Plant Physiol. 13: 695-712, 1938.

80. McLean, E. O. Plant growth and uptake of nutrients as influenced by levels of nitrogen. Soil Sci. Soc. Am. Proc. 21: 219-222, 1957.

81. McVickar, M. H., and Shear, G. M. Variations in response of different varieties and hybrids of field corn to planting rate. Jour. Am. Soc. Agron. 38: 933-935.

82. Mederski, H. J., and Wilson, J. H. Relation of soil moisture to ion absorption by corn plants. Soil Sci. Soc. Am. Proc. 24: 149-152, 1960.

83. Millar, C. E., Cook, R. L., Robertson, L. S., Rood, P. J., Cumings, G. A., and Hulbert, W. C. The effect of fertilizers plowed under and applied under the row and the effect of nitrogen fertilizer applied as a side-dressing on the yields of corn at the Michigan Experiment Station in 1946. Proc. 22nd Ann. Meet. Natl. Joint Comm. on Fert. Appl: 168-179, 1946.

84. ____________, Robertson, L. S., Cook, R. L., Hansen, C. M., Hulbert, W. C., and Cumings, G. A. The effect of fertilizer placement on the yield and maturity date of corn at the Michigan Experiment Station in 1947. Proc. 23rd Ann. Meet. Natl. Joint Comm. on Fert. Appl. 129-133, 1947.

85. Miller, M. F., and Duley, F. L. The effect of a varying moisture supply upon the development and composition of the maize plant at different periods of growth. Missouri Agr. Exp. Sta. Res. Bull. 76, 1925.

86. Miller, M.H. and Ohlrogge, A. J. Principles of nutrient uptake from the fertilizer bands: I. Effect of placement of nitrogen fertilizer on the uptake of band-placed phosphorus at different soil phosphorus levels. Agron. Jour. 50: 95-97, 1958.

87. Montgomery, E. G., and Kiesselbach, T. A. Studies in water requirements of corn. Nebraska Agr. Exp. Sta. Bull. 128, 1912.

88. Mooers, C. A. The influence of soil productivity on the order of yield in a varietal trial of corn. Jour. Am. Soc. Agron. 25: 796-800, 1933.

89. Moss, D. N., and Stinson, H. T. Differential response of corn hybrids to shade. Crop Sci. 1: 416-418, 1961.

90. Nelson, W. L., Krantz, B. A., Welch, C. D., and Hall, N. S. Utilization of Phosphorus as affected by placement: II. Cotton and corn in North Carolina. Soil Sci. 68: 137-144, 1949,

91. Norden, A. J. Response of field corn varieties to plant populations and planting dates on Flatwood soil. Soil and Crop. Sci. Soc. Fla. Proc. 21: 213-220, 1961.

92. Ohlrogge, A. J., Krantz, B. A., and Scarseth, G. D. The recovery of plowed-under ammonium sulfate by corn. Soil Sci. Soc. Am. Proc. 8: 196-200, 1944.

93. Olsen, S. R., Schmehl, W. R., Watanabe, F. S., Scott, C. O., Fuller, W. H., Jordan, J. V., and Kunkel, R. Utilization of phosphorus by various crops as affected by source of material and placement. Colorado Agr. Exp. Sta. Tech. Bull. 42, 1950.

94. ____________, Watanabe, F. S., and Danielson, R. E. Phosphorus absorption by corn roots as affected by moisture and phosphorus concentration. Soil Sci. Soc. Am. Proc. 25: 289-294, 1961.

95. Patrick, W. H., Jr., Sloane, L. W., and Phillips, S. A. Response of cotton and corn to deep placement of fertilizer and deep tillage. Soil Sci. Soc. Am. Proc. 23: 307-310, 1959.

96. Pendleton, J. W., Dungan, G. H., Koehler, B., Bigger, J. H., Lang, A. L., Jugenheimer, R. W., and McKibben, G. E. 1951 Illinois tests of corn hybrids in wide use. Illinois Agr. Exp. Sta. Bull. 552, 1952.

97. Pesek, J., and Dumenil, L. How much fertilizer pays? Iowa Farm Sci. 7: 3-6, 1953.

98. Peters, D. B. Growth and water absorption by corn as influenced by soil moisture tension, moisture content, and relative humidity. Soil Sci. Soc. Am. Proc. 24: 535-526, 1960.

99. Prine, G. M., Schroder, V. N., West, S. H., Butson, K. D., and Ruelke, O. C. Measurement of meterological elements of the microclimate. Florida Agr. Exp. Sta. Ann. Rept. 56-58, 1959.

100. ________. Light, a factor to be considered in growing corn. Soil and Crop Sci. Soc. Fla. Proc. 21: 221-228, 1961.

101. Prummel, J. Fertilizer placement experiments. Plant and Soil 8: 231-253, 1957.

102. ________. Placement of a compound (N.P.K.) fertilizers compared with straight fertilizers. Netherland Jour. Agr. Sci. 8:149-154, 1960.

103. Pumphrey, F. V., and Harris, L. Nitrogen fertilizer for corn production on an irrigated chestnut soil. Agron. Jour. 48: 207-212, 1956.

104. Ratliff, L. 304.37 bushels of corn from one acre. Plant Food Review. 1: 35, 1955.

✓ 105. Reichman, G. A., Grunes, D. L. Carlson, C. W., and Alessi, J. Nitrogen and phosphorus composition and yield of corn as affected by fertilization. Agron. Jour. 51: 575-578, 1959.

106. Reid, P.H., and York, E. T. The relative growth and potassium absorption by four crops under intensive culture in a limited volume of soil. Soil Sci. Soc. Am. Proc. 19: 481-483, 1955.

107. Reith, J. W. S. Recent advances in fertilizer placement: I. Fertilizer placement for swedes and turnip in Scotland. Jour. Sci. Food Agr. 5: 421-428, 1954.

108. Rhoades, H. F., Bondurant, J. A., Hamilton, F. B., and Howe, O. W. Fertilization and irrigation practices for corn production on newly irrigated land in the Republican Valley. Nebraska Agr. Exp. Sta. Bull. 424, 1954.

109. Richards, L. A., and Wadleigh, C. H. Soil water and plant growth. *In* B. T. Shaw, ed., Soil Physical Conditions and Plant Growth. Academic Press, Inc., New York, pp. 203-204, 1952.

110. Rickey, F. D. Corn culture. USDA Farmers' Bull. 1714: 18-20, 1933.

111. Robertson, L. W., Hansen, C. M., Dudley, R. F., Brown, H. M., and Foth, H. D. Growth and yield characteristics of spring oats and winter wheat as affected by various placements of fertilizer. Proc. 35th Ann. Meet. Natl. Joint Comm. on Fert. Appl. 19-30, 1959.

112. Robertson, W. K., Smith, P. M., Ohlrogge, A. J., and Kinch, D. M. Phosphorus utilization by corn as affected by placement and nitrogen and potassium fertilization. Soil Sci. 77: 219-226, 1954.

113. ______________, Fiskell, J. G. A., Hutton, C. E., Thompson, L. G., Lipscomb, R. W., and Lundy, H. W. Results from subsoiling and deep fertilization of corn for 2 years. Soil Sci. Soc. Am. Proc. 21: 340-346, 1957.

114. ______________, and Lundy, H. W. Factors limiting field corn production in North Central Florida. Soil and Crop Sci. Soc. Fla. Proc. 20: 306-316, 1960.

115. ______________, Schroder, V. N., Lundy, H. W., and Prine, G. M. Carbon dioxide as it effects corn yields. Soil and Crop Sci. Soc. Fla. Proc. 21: 229-237, 1961.

116. Robins, J. S., and Domingo, C. E. Some effects of severe soil moisture deficits at specific growth stages in corn. Agron. Jour. 45: 618-621, 1953.

117. Salter, R. M. Our heritage, the soil. Ohio Agr. Exp. Sta. Bull. 175, 1946.

118. Sayre, C. B., and Clark, A. W. Rates of solution and movement of different fertilizers in the soil and the effects of fertilizers on germination and root development of beans. New York Agr. Exp. Sta. Tech. Bull. 231, 1935.

119. Sayre, J. D. Mineral accumulation in corn. Plant Physiol. 23: 267-281, 1948.

120. Schwab, G. O., Shrader, W. D., Nixon, P. R., and Shaw, R. H. Research on irrigation of corn and soybeans at Conesville and Ankeny, Iowa, 1951 to 1955. Iowa Exp. Sta. Res. Bull. 458: 245-249, 1958.

121. Seem, B. L., and Huber, L. L. Corn planting rates, soil productivity and yield. Pennsylvania Agr. Exp. Sta. Bull. 480, Sup. 3: 7, 1947.

122. Shalhevet, J., and Zwerman, P. J. Nitrogen response of corn under variable conditions of drainage - a preliminary greenhouse study. Soil Sci. 85: 225-260, 1958.

123. __________, and ______________. Nitrogen response of corn under variable conditions of drainage - a lysimeter study. Soil Sci. 93: 172-182, 1962.

124. Singh, R. M., and Black, C. A. Test of the DeWit compensation function for estimating the value of different fertilizer placements. Agron. Jour. 56: 572-574, 1964.

125. Singleton, H. P., Viets, F. G., Leamar, R. W., Menzies, J. D., Nelson, C. E., Clore, W. J., Larson, C. A., Domingo, C. E., and Olsen, S. R. Soil, water and crop management investigations in the Columbia Basin Project. Washington Agr. Exp. Sta. Bull. 520, 1950.

126. Sites, J. W., Hammond, L. C., Leighty, R. G., and Johnson, W. O. Information to consider in the use of soils of flatwoods and marshes for citrus. Florida Agr. Exp. Sta. Circ. S-135, 1961.

127. Smith, F. B. Some effects of method of application of fertilizers on corn and soils. Iowa Agr. Exp. Sta. Res. Bull. 104, p. 66, 1927.

128. Smith, F. W. The effect of time, rate and method of application of fertilizer on the yield and quality of hard red winter wheat. Soil Sci. Soc. Am. Proc. 12: 262-265, 1947.

129. Smith, G. E. Soil fertility and crop production. Missouri Agr. Exp. Sta. Bull. 583, 1952.

130. Speer, R. J., Allen, S. E., Maloney, M., and Roberts, A. Phosphate fertilizers for the Texas blacklands: I. Relative availability of various phosphatic fertilizers. Soil Sci. 72: 459-464, 1951.

131. Stanberry, C. O., Schreiber, H. A., Lowrey, M., and Jenson, C. L. Sweet corn production as affected by moisture and nitrogen variables. Agron. Jour. 55: 159-161, 1963.

132. Stanford, G., and Nelson, L. B. Utilization of phosphorus as affected by placement: I. Corn in Iowa Soil Sci. 68: 129-135, 1949.

133. Steenbjerg, F. A theory on the placement of fertilizers. Royal Veterinary and Agricultural College Yearbook, 1957, pp. 1-30, Copenhagen, Denmark, 1957

134. Stinson, H. T., and Moss, D. N. Some effects of shade upon corn hybrids tolerant and intolerant of dense planting. Agron. Jour. 52: 482-484, 1960.

135. Terman, G. L., DeMent, L. D., and Engelstad, O. P. Crop response to fertilizers varying in solubility of the phosphorus, as affected by rate, placement and seasonal environment. Agron. Jour. 53: 221-224, 1961.

136. Termunde, D. E., Shank, D. B., and Dirks, V. A. Effects of population levels on yield and maturity of maize hybrids grown on the Northern Great Plains. Agron. Jour. 55: 551-555, 1963.

137. Thompson, L. G., Jr., Lipscomb, R. W., and Robertson, W. K. Twelve years' programs on general field crops in Northern Florida Soil and Crop Sci. Soc. Fla. Proc. 19:240-255, 1959.

138. Tyner, E. H. The relation of corn yields to leaf nitrogen phosphorus and potassium content. Soil Sci. Soc. Am. Proc. II: 317-323, 1946.

139. Vazquez, R. Effects of irrigation, nitrogen levels and plant population on corn yields in Layas Valley, Puerto Rico. Jour. Agr. Univ. Puerto Rico 44: 121-137, 1960.

140. Verma, R. D., and Sharma, J. C. Effect of different doses of nitrogen and phosphorus placed and broadcast and of row spacings in maize. Indian Jour. Agr. Sci. 28: 13-20, 1958.

141. Viets, F. G., Jr., and Domingo, C. E. Yields and nitrogen content of corn hybrids as affected by nitrogen supply. Soil Sci. Soc. Am. Proc. 13: 303-306, 1949.

142. ____________, Nelson, C. E., and Crawford, C. L. The relationships among corn yields, leaf composition and fertilizers applied. Soil Sci. Soc. Am. Proc. 18: 297-301, 1954.

143. Wallace, R. W. Cooperative fertilizer experiments with field crops and pastures. Florida Agr. Exp. Sta. Ann. Rept. 229-230, 1949.

144. Warner, J. D., Wallace, R. W., Smith, R. L., Lipscomb, R. W., Killinger, G. B., Paddick, M. E., and Stokes, W. E. Corn fertilizer experiments. Florida Agr. Exp. Sta. Ann. Rept. p. 40, 1948.

145. Weidemann, A. G., and Millar, C. E. Results from longtime field experiments on soil. Michigan Agr. Exp. Sta. Spec. Bull. 366, 1951.

146. Welch, C. D., Hall, N. S., and Nelson, W. L. Utilization of fertilizer and soil phosphorus by soybeans. Soil Sci. Soc. Am. Proc. 14: 231-235, 1949.

147. Widtsoe, J. A. Irrigation investigations; factors influencing evaporation and transpiration. Utah Agr. Exp. Sta. Bull. 105, 1909.

148. Wittels, H., and Seatz, L. F. Effect of potash fertilization on yield stalk breakage and mineral composition of corn. Soil Sci. Soc. Am. Proc. 17: 369-371, 1953.

✓149. Wofford, I. M., Horner, E. S., and McCloud, D. E. Plant populations, date of planting and nitrogen levels for field corn. Soil and Crop Sci. Soc. Fla. Proc. 16: 352-359, 1956.

150. Yuen, S. H., and Pollard, A. G. The availability of soil phosphate. IV. Effect of nitrogen on the utilization of phosphate by Italian rye grass. Jour. Sci. Food Agr. 8: 475-582, 1957.

APPENDIX

TABLE 20

Mutually orthogonal coefficients for decomposing the fertility treatment sum of squares

Fertility treatment comparison	Check	Coefficients										
		Broadcast					Localized placement					
		6-inch			3-inch		50 per cent			25 per cent		
		4000	2000	1000	2000	1000	2000	1000	500	2000	1000	500
Mean	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
Broadcast												
a. 3 vs. 6 in.	0	+2	+2	+2	-3	-3	0	0	0	0	0	0
b. 1000 vs. 2000 (3 in.)	0	0	0	0	+1	-1	0	0	0	0	0	0
c. Linear	0	+5	-1	-4	0	0	0	0	0	0	0	0
d. Quadratic	6	+1	-3	+2	0	0	0	0	0	0	0	0
Placed (25%)												
e. Linear	0	0	0	0	0	0	0	0	0	+5	-1	-4
f. Quadratic	0	0	0	0	0	0	0	0	0	+1	-3	+2
Placed (50%)												
g. Linear	0	0	0	0	0	0	+5	-1	-4	0	0	0
h. Quadratic	0	0	0	0	0	0	+1	-3	+2	0	0	0
Placed												

TABLE 20 (Continued)

Fertility treatment comparison	Check	Coefficients										
		Broadcast					Localized placement					
		6-inch			3-inch		50 per cent			25 per cent		
		4000	2000	1000	2000	1000	2000	1000	500	2000	1000	500
i. 25 vs. 50%	0	0	0	0	0	0	+1	+1	+1	-1	-1	-1
j. Check vs. others	-11	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1	+1
k. Broadcast vs. placement	0	+6	+6	+6	+6	+6	-5	-5	-5	-5	-5	-5

TABLE 21

Analyses of variance for grain, forage and total dry matter of corn on Leon fine sand, 1963

Sources of variation	Degrees of freedom	Mean squares		
		Grain	Forage	Total dry matter
Block (B)	3	4973	63729772	218295630
Treatment (T)	71	3687	190676851	447677965
Fertility (F)	11	18422[a]	473905693[a]	2360045310[a]
Population (P)	2	3344[a]	911421572[a]	682866811[a]
Hybrid (H)	1	21816[a]	5445368257[a]	1630062680[a]
F X P	22	391	19592711	52725606
F X H	11	843[c]	28699151[c]	26481344
P X H	2	544	23458069	88098168
F X P X H	22	530	11965270	54608470
Error (E)	213	424	14301646	48198572
Total	287			

[a] Significant at 0.001 level of probability - highly significant.

[b] Significant at 0.01 level of probability - very significant.

[c] Significant at 0.05 level of probability - significant.

TABLE 22

Treatment comparisons for fertility and population rate for grain, forage and total dry matter of corn on Leon fine sand, 1963.

Source of variation	Degrees of freedom	Mean squares		
		Grain	Forage	Total dry matter
Fertility (F)	11	18421[a]	473905693[a]	2360045310[a]
a	1	67	28230498	13650158
b	1	3145[b]	170789926[a]	598608819[a]
c	1	787	161171620[a]	48763610
d	1	1034	87776748[c]	251498814[c]
e	1	19952[a]	485636473[a]	2551964316[a]
f	1	2048[c]	1200818	103953111
g	1	16212[c]	564962178[a]	2445141659[a]
h	1	1524	1681303	83625212
i	1	579	20970648	71418
j	1	149993[a]	3423021485[a]	18730980684
k	1	7297[d]	26520931[a]	1132240608[a]
Population (P)[d]	2	3344[a]	911421572[a]	682866811[a]
a_1	1	2580[c]	1793669359[a]	1031610774[a]
b_1	1	4108[b]	29173784	334122847[b]
Error (E)	213	424	14301646	48198572

[a] Significant at 0.001 level of probability - highly significant.

[b] Significant at 0.01 level of probability - very significant.

[c] Significant at 0.05 level of probability - significant.

[d] The orthogonal comparison between low and high plant population is designated by a_1, and between average of low and high plant populations and medium plant population by b_1.

TABLE 23

Analyses of variance of phosphorus content of corn on Leon fine sand, 1963.

Source of variation	Degrees of freedom	Mean squares		
		Phosphorus in corn ear	Phosphorus in forage	Total phosphorus content
Blocks (B)	3	87	128	18
Treatments (T)	71	79	49	133
Fertility (F)	11	387^a	134^a	665^a
Population (P)	2	115^b	279^a	89^c
Hybrid (H)	1	120^b	977^a	412^a
F X P	22	11	9	25
F X H	11	20	7	13
P X H	2	103^b	8	170^b
F X P X H	22	15	10	23
Error (E)	213	18	9	26
Total	287			

[a] Significant at 0.001 level of probability - highly significant.

[b] Significant at 0.01 level of probability - very significant.

[c] Significant at 0.05 level of probability - significant.

TABLE 24

Treatment comparisons of fertility and population rate for the phosphorus content of corn on Leon fine sand, 1963.

Source of variation	Degrees of freedom	Mean squares Phosphorus in corn ear	 Phosphorus in forage	 Total phosphorus content
Fertility (F)	11	387^{a}	134^{a}	665^{a}
a	1	214^{a}	157^{a}	4
b	1	109^{c}	49^{c}	305^{a}
c	1	20	738^{a}	515^{a}
d	1	25	9	4
e	1	620^{a}	117^{a}	1275^{a}
f	1	31	41^{c}	1
g	1	190^{b}	64^{b}	474^{a}
h	1	35	1	31
i	1	27	35^{c}	1
j	1	2455^{a}	71^{b}	3357^{a}
k	1	530^{a}	187^{a}	1345^{a}
Population (P)^{d}	2	114^{b}	279^{a}	89^{c}
a_1	1	129^{b}	542^{a}	143^{c}
b_1	1	100^{c}	17	35
Error (E)	213	18	9	26

[a] Significant at 0.001 level of probability - highly significant.

[b] Significant at 0.01 level of probability - very significant.

[c] Significant at 0.05 level of probability - significant.

[d] The orthogonal comparison between low and high plant population is designated by a_1 and between average of low and high plant populations and medium plant populations by b_1.

TABLE 25

Analyses of variance of potassium content of corn on Leon fine sand, 1963.

Source of variation	Degrees of freedom	Mean squares		
		Potassium in corn ear	Potassium in forage	Total potassium content
Blocks (B)	3	424	1198	2969
Treatments (T)	71	522	6201	7066
Fertility (F)	11	1343^{a}	30322^{a}	40419^{a}
Population (P)	2	318^{b}	2193^{b}	1988^{c}
Hybrid (H)	1	17353^{a}	69621^{a}	17455^{a}
F X P	22	23	367	471
F X H	11	224^{a}	1559^{a}	1305^{c}
P X H	2	41	291	551
F X P X H	22	55	314	446
Error (E)	213	41	422	554

[a] Significant at 0.001 level of probability - highly significant.

[b] Significant at 0.01 level of probability - very significant.

[c] Significant at 0.05 level of probability - significant.

TABLE 26

Treatment comparisons of fertility and population rate for the potassium content of corn on Leon fine sand, 1963.

Source of variation	Degrees of freedom	Potassium in corn ear	Potassium in forage	Total potassium content
Fertility (F)	11	1343[a]	30322[a]	40419[a]
a	1	1264[a]	13320[a]	22791[a]
b	1	225[c]	18922[a]	23275[a]
c	1	99	89522[a]	83681[a]
d	1	116	604	1251
e	1	1830[a]	46054[a]	66244[a]
f	1	121	401	82
g	1	1010[a]	31658[a]	43980[a]
h	1	174[c]	227	798
i	1	68	42	3
j	1	9831[a]	83333[a]	150375[a]
k	1	35	49460[a]	52130[a]
Population (P)[d]	2	318[b]	2193[b]	1988[c]
a_1	1	183[c]	4125[b]	2573
b_1	1	453[a]	262	1404[c]
Error (E)	213	41	422	554

[a] Significant at 0.001 level of probability - highly significant.

[b] Significant at 0.05 level of probability - very significant.

[c] Significant at 0.01 level of probability - significant.

[d] The orthogonal comparison between low and high plant population is designated by a_1 and between average of low and high plant population and medium plant population by b_1.

TABLE 27

Corn grain yield of DeKalb 805 and Florida 200 in relation to fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Grain yield, bu./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	25	8	65	40	34	9	2	51	40	25
	2	75	1	11	18	30	41	13	83	108	61
	3	24	0	10	1	9	7	7	4	56	18
4/100	1	144	103	130	98	119	123	66	131	96	104
	2	150	137	129	135	138	113	68	97	75	88
	3	84	64	135	126	102	128	108	116	104	114
2/100	1	130	143	109	123	126	100	80	105	97	95
	2	159	118	143	137	139	146	124	115	117	125
	3	149	110	193	122	143	97	65	145	126	108
1/100	1	106	147	148	112	128	135	111	102	79	107
	2	140	140	154	143	144	116	126	68	112	105
	3	120	137	106	139	125	117	73	88	87	91
2/50	1	129	143	146	114	133	111	110	120	123	116
	2	139	107	178	145	142	153	78	128	136	124
	3	139	122	150	96	127	126	113	113	107	120
2/100, 3 in.	1	147	149	134	146	144	126	116	120	128	122
	2	144	108	143	155	137	91	120	152	67	107
	3	154	128	131	164	144	92	125	150	46	103

TABLE 27 (Continued)

Fertility treatment[a]	Plant population[b]	Grain yield, bu./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	94	127	134	110	116	107	102	115	133	114
	2	122	123	139	117	125	133	101	37	119	122
	3	121	102	113	113	112	70	66	95	81	78
1/100, 3 in.	1	151	107	105	107	117	113	70	106	145	108
	2	109	96	143	117	116	117	92	145	116	117
	3	105	95	111	130	110	113	72	70	113	92
0.5/50	1	102	83	114	101	100	73	40	80	74	67
	2	89	102	95	74	90	70	77	141	105	98
	3	108	74	156	104	110	40	69	95	62	66
2/25	1	155	158	121	139	143	100	141	94	154	122
	2	137	128	111	108	121	129	106	103	140	119
	3	109	109	172	138	132	156	76	126	84	110
1/25	1	139	113	112	112	119	75	106	107	106	108
	2	117	123	124	108	118	108	77	119	121	106
	3	108	88	131	109	109	75	59	112	104	87
0.5/25	1	88	107	93	92	95	70	61	80	92	76
	2	112	88	106	99	101	90	48	65	79	70
	3	78	102	113	68	90	52	80	52	56	60

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant populations were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 28

Corn forage yield of DeKalb 805 and Florida 200 in relation to fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Forage yield, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	2078	3220	2793	3957	2987	2224	1644	3643	4729	3060
	2	3235	3605	2694	2742	3069	5055	2143	7141	6656	5249
	3	4126	1309	2857	2791	2791	3181	2978	3427	2410	3427
4/100	1	6587	4746	3950	4499	4945	12390	5986	6807	9788	8753
	2	8150	7551	7191	7006	7474	9462	8039	11293	8747	8395
	3	9665	7037	8383	6756	7710	10857	10845	10726	14306	11659
2/100	1	4898	6125	3992	4867	4970	8338	8318	9496	7241	8323
	2	7440	6034	6104	5869	6362	9693	11066	9496	9068	9831
	3	9767	9006	8031	7186	8497	11874	10577	9803	12789	11261
1/100	1	4201	5859	4753	4071	4716	9635	7127	7615	7015	7848
	2	5556	6401	5956	5036	5737	10726	7796	6618	7316	8114
	3	6501	7829	4748	6607	6421	9618	9824	9015	8668	9281
2/50	1	4627	6499	5113	4702	5235	8540	8860	7909	8816	8531
	2	8510	6732	7114	5922	7077	10757	9180	10231	10206	10093
	3	8495	7860	7224	6238	7454	10338	9411	10020	11669	10359
2/100, 3 in.	1	6391	5895	4936	4909	5533	8629	9730	8079	7060	8374
	2	7426	4990	6702	7409	6633	9753	10454	11725	6435	9590
	3	7968	8063	8470	6634	7784	8754	11425	15586	6644	10877

TABLE 28 (Continued)

Fertility treatment[a]	Plant population[b]	Forage yield, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	4276	5528	4497	2178	4120	6382	6605	7435	9110	7383
	2	5861	5616	5573	4989	5510	9077	7954	7663	7051	7936
	3	6795	7786	5946	5735	6565	8443	10133	8610	9816	9250
1/100, 3 in.	1	5953	4220	4299	2769	4310	7221	6078	7234	8785	7329
	2	6786	5730	5117	5118	5688	9877	8317	8389	9035	8904
	3	9999	6002	5376	7018	7249	8863	7427	6813	9515	8154
0.5/50	1	4180	3986	3915	4766	4212	6284	4930	6175	5570	5740
	2	4670	5027	4108	4297	4525	7935	6951	10179	8610	8419
	3	6099	4685	5760	4470	5253	6911	10177	7367	6263	7682
2/25	1	4868	6270	4324	5282	5186	8962	10816	7487	9925	9297
	2	6416	6870	5062	5459	5952	10191	10444	7993	10062	9897
	3	7640	9525	9695	6808	8416	12265	12236	10677	9630	10952
1/25	1	5023	4840	4120	4455	4609	7404	8834	7459	8093	7974
	2	5035	4641	5048	5630	5338	8109	10792	8866	9774	9385
	3	6507	6118	5486	6536	6162	9907	8155	8424	8758	8811
0.5/25	1	4451	5527	3753	3667	4349	5927	6984	5456	7442	6452
	2	6196	4634	4314	3942	4770	8333	7500	6227	7282	7483
	3	6753	6417	6304	6714	6545	9102	10023	6925	6040	8032

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant populations were 19,360, 27,922, and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 29

Corn total dry matter yield of DeKalb 805 and Florida 200 in relation to fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Total dry matter, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	3794	3750	6991	6441	5221	2804	1758	6883	7262	4677
	2	8081	3700	3415	3885	4770	7655	2973	12409	13517	9238
	3	6577	1309	3500	2947	3358	3609	2839	3217	8706	4593
4/100	1	15863	11413	11332	10811	12605	10242	10146	15113	15863	15316
	2	17855	16359	15495	15705	16353	16581	12354	17419	13497	14963
	3	15059	11184	16117	14861	14305	18824	17677	18036	20861	18849
2/100	1	13293	15364	11038	12833	13132	14678	13359	16051	13354	15460
	2	17677	13670	15333	14703	15346	18922	18893	16737	16486	17759
	3	19459	16115	20471	15076	17755	17987	14711	18941	20767	18101
1/100	1	11020	15325	14277	11319	12985	18180	14148	14081	12019	14607
	2	14581	15453	15907	14265	15051	18036	15787	10905	15396	14787
	3	14240	16639	11580	15606	14516	17004	14450	14561	14201	15054
2/50	1	12958	15738	14528	12050	13818	15560	15792	15471	16578	15848
	2	17453	13634	18605	15300	16258	20436	14107	18344	18836	17931
	3	17369	15725	16904	11414	15628	18329	16545	18501	18450	17931
2/100, 3 in.	1	15582	15486	13570	14300	14809	16607	17078	15692	15152	16132
	2	16710	11933	15937	17401	15495	15497	18064	21308	10655	16281
	3	17963	16318	16953	17183	17092	15602	19454	25102	9659	17432
1/50	1	10313	13733	13199	9261	11606	13125	13033	14742	17505	14601
	2	13729	13555	15444	12530	13589	17489	13211	16348	14551	15674
	3	13253	14571	13269	12021	13803	12892	14292	14622	14933	14185

TABLE 29 (Continued)

Fertility treatment[a]	Plant population[b]	Total dry matter, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/100, 3 in.	1	15695	11127	11106	9677	11901	14355	10514	13952	17948	14192
	2	13796	11951	14319	12646	13178	17255	14130	17550	16399	16333
	3	16780	12715	12548	15437	14370	15997	11952	11250	16662	13965
0.5/50	1	10772	9330	11251	11257	10652	10910	7464	11242	10271	9972
	2	10428	11588	10248	9048	10328	12373	11810	19123	15181	14647
	3	13057	9642	15818	11176	12378	9457	14513	13354	10218	11885
2/25	1	14863	16554	11101	14218	14409	15301	19702	13436	19681	17030
	2	15264	15119	12222	12402	13752	19244	17141	14487	18924	17449
	3	14673	16571	20824	15692	16940	22160	16063	18656	14924	17951
1/25	1	13959	12113	11218	11677	12266	14487	15527	14253	14811	14769
	2	12604	13577	13045	12600	12956	14929	11911	19533	15312	14344
	3	13502	11828	13909	13556	13911	14521	11911	16366	17438	16103
0.5/25	1	10111	12446	9727	9603	10472	10351	10853	10498	13379	11270
	2	13398	10210	11157	10299	11291	14501	10562	10365	13295	12068
	3	11808	12971	13589	11126	12373	12392	15064	10820	9681	11829

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant populations were 19,360, 27,922, and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 30

Phosphorus content of corn ear in relation to hybrid fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Phosphorus content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	3.04	0.90	9.97	4.89	4.70	1.39	0.42	8.16	4.43	3.60
	2	7.98	0.21	1.44	2.09	2.93	5.38	1.20	14.49	17.97	9.76
	3	4.13	0.02	1.25	0.14	1.38	1.08	0.64	0.51	5.34	1.88
4/100	1	19.49	13.66	13.82	14.05	15.25	19.96	11.44	14.73	12.12	14.56
	2	15.27	14.53	14.51	15.18	14.87	23.45	7.74	14.57	6.99	13.18
	3	11.71	8.60	13.74	14.17	12.05	16.10	11.94	13.71	16.70	14.61
2/100	1	23.04	24.19	11.93	15.52	18.67	9.17	13.21	30.78	10.70	15.96
	2	18.67	15.24	15.70	16.33	16.48	14.78	17.60	19.85	10.20	15.61
	3	18.71	12.41	21.73	17.66	17.63	9.17	6.50	13.59	18.94	11.82
1/100	1	14.29	15.59	19.07	13.23	15.54	20.79	17.12	11.60	10.50	14.88
	2	20.29	17.16	17.63	19.34	18.60	13.35	16.95	7.06	12.39	12.39
	3	14.51	17.59	11.27	18.00	15.34	22.69	6.82	12.48	13.00	13.75
2/50	1	15.62	15.20	16.47	16.13	15.85	16.67	11.09	13.60	11.62	13.24
	2	13.36	13.10	18.60	17.79	15.71	18.14	11.69	17.60	22.65	17.52
	3	14.11	15.70	17.67	15.72	18.87	17.17	13.56	13.56	12.39	15.50
2/100, 3 in.	1	20.88	28.29	18.99	21.12	22.32	13.56	17.08	14.46	18.81	15.98
	2	15.09	17.35	27.69	11.49	17.90	16.51	16.74	28.27	14.77	19.07
	3	29.83	28.48	22.05	24.64	15.35	22.20	14.51	18.20	11.40	15.86
1/50	1	11.48	16.61	14.65	20.24	25.74	20.90	12.05	15.71	17.56	16.55
	2	11.96	13.88	12.53	14.24	13.12	11.75	8.72	12.15	10.61	10.81
	3	15.33	9.18	12.45	16.38	11.56	13.38	11.91	26.85	13.87	16.05

TABLE 30 (Continued)

Fertility treatment[a]	Plant population[b]	Phosphorus content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/100, 3 in.	1	25.57	18.65	12.42	16.75	18.35	16.59	9.76	18.47	21.30	16.54
	2	16.82	15.55	30.34	18.82	17.86	20.66	9.88	28.40	16.20	17.78
	3	20.68	14.67	9.86	16.84	15.51	15.69	8.60	6.76	11.61	10.66
0.5/50	1	13.13	16.41	12.80	12.16	13.62	12.92	4.12	9.10	7.29	8.36
	2	10.08	9.84	17.61	9.29	11.45	10.53	8.26	29.51	9.16	14.36
	3	12.00	8.83	14.08	16.25	12.79	5.72	9.07	8.66	6.91	7.59
2/25	1	20.49	19.42	15.51	15.63	17.79	15.54	16.66	13.07	21.91	16.79
	2	15.00	17.52	17.17	12.65	15.58	21.40	14.87	12.97	29.23	19.54
	3	12.99	13.56	21.11	18.65	16.58	19.24	10.14	12.53	9.25	12.79
1/25	1	15.17	10.90	14.92	13.49	13.62	11.71	9.85	17.61	17.61	12.49
	2	14.19	12.87	15.57	9.22	12.96	14.99	7.70	17.99	23.32	16.00
	3	12.76	11.42	16.00	14.01	13.55	7.99	6.56	12.05	11.13	9.43
0.5/25	1	9.60	10.55	9.38	9.64	9.79	9.79	8.29	9.87	8.56	8.90
	2	10.78	8.36	11.63	13.48	11.06	15.30	4.82	6.41	7.89	8.60
	3	6.92	10.31	11.48	7.27	8.99	9.20	6.93	5.22	8.41	7.44

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant population rates were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 31

Phosphorus content of corn forage in relation to hybrid, fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Phosphorus content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	2.28	4.54	1.26	6.01	3.52	2.48	2.86	4.09	6.31	3.93
	2	1.70	4.62	3.23	5.26	3.70	6.11	3.96	6.06	8.07	6.05
	3	6.19	0.54	2.86	5.49	3.77	7.22	5.63	6.96	5.44	6.31
4/100	1	4.34	17.80	1.78	11.25	8.79	13.62	12.41	6.13	14.10	11.56
	2	3.95	6.30	12.83	6.94	7.50	25.69	8.22	11.00	10.05	13.74
	3	20.69	30.26	9.51	12.80	18.31	10.48	24.67	13.37	15.36	15.97
2/100	1	1.71	1.53	1.47	2.82	1.88	3.71	15.29	9.39	11.71	9.90
	2	3.35	8.44	3.05	2.86	4.42	4.76	10.79	7.59	5.16	7.32
	3	4.69	13.06	3.00	6.00	6.84	14.24	12.95	5.29	10.35	10.71
1/100	1	2.52	2.05	1.54	1.63	1.93	5.16	3.38	3.73	6.45	4.68
	2	2.92	4.38	2.02	2.41	2.93	5.94	5.92	5.95	7.75	6.39
	3	3.57	5.00	2.85	3.83	3.81	11.44	13.46	6.67	12.11	10.92
2/50	1	2.20	5.13	2.04	1.88	2.81	8.53	10.40	5.64	5.07	7.41
	2	2.59	7.40	2.32	2.31	3.65	9.24	13.31	5.98	8.67	9.30
	3	4.67	6.01	5.24	12.85	7.19	8.01	5.78	5.50	11.90	7.80
2/100, 3 in.	1	3.32	8.16	2.07	3.29	4.21	8.63	6.47	4.36	5.89	6.34
	2	3.86	2.59	4.63	4.44	3.88	12.82	10.61	9.50	5.31	9.56
	3	3.98	8.06	5.84	4.15	5.51	9.17	11.24	9.35	17.41	11.79

TABLE 31 (Continued)

Fertility treatment	Plant population[b]	Phosphorus content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	2.09	2.49	1.46	2.12	2.04	3.12	5.61	5.69	6.65	5.27
	2	2.93	3.37	2.09	2.44	2.71	3.31	5.65	4.02	4.40	4.34
	3	3.99	8.84	2.14	5.16	5.03	6.95	9.01	5.42	15.69	9.27
1/100, 3 in.	1	1.93	1.69	2.41	1.73	1.94	4.48	5.38	4.70	6.41	5.24
	2	1.70	6.22	2.56	4.14	3.65	8.74	9.06	4.19	6.59	7.14
	8	8.30	5.48	3.84	2.81	5.11	6.47	6.31	6.98	4.38	6.03
0.5/50	1	1.98	1.59	1.27	2.74	1.89	3.76	5.17	3.15	3.29	3.84
	2	1.82	2.26	2.38	1.83	2.07	7.29	6.94	3.61	7.40	6.31
	3	3.66	3.04	1.73	2.84	2.82	7.60	13.07	3.97	6.42	7.76
2/25	1	1.46	4.06	2.92	2.37	2.70	11.87	8.31	4.04	6.64	7.71
	2	4.17	7.80	1.97	4.09	4.51	13.73	20.87	6.59	7.94	12.28
	3	6.87	18.85	5.09	5.78	9.15	9.99	22.06	7.30	10.34	12.42
1/25	1	2.00	2.10	1.24	1.33	1.67	4.99	3.58	4.40	11.64	6.64
	2	2.14	2.26	2.35	2.19	2.23	3.97	10.79	5.54	5.86	6.54
	3	3.73	5.32	3.13	3.78	3.99	6.93	12.01	5.25	5.87	7.51
0.5/25	1	2.22	2.40	1.03	1.83	1.87	6.07	6.58	2.40	5.80	5.21
	2	3.87	1.97	3.89	2.07	2.95	5.46	8.99	4.73	9.26	7.36
	3	3.37	5.45	2.99	11.35	5.79	14.91	6.76	9.16	6.39	9.30

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant population rates were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3 respectively.

TABLE 32

Phosphorus content of the total corn plant in relation to hybrid, fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Phosphorus content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	5.32	5.44	11.22	10.90	8.22	3.87	3.28	12.25	10.75	7.54
	2	9.68	4.83	4.67	7.35	6.63	11.80	5.16	20.55	26.04	15.81
	3	10.32	0.79	4.11	5.63	5.21	8.24	6.27	7.47	10.78	8.19
4/100	1	23.83	31.45	15.59	25.30	24.04	33.58	23.85	20.86	26.21	26.12
	2	19.22	20.83	27.34	22.11	22.37	49.14	15.97	25.56	17.05	26.93
	3	32.40	38.87	23.25	26.97	30.37	26.58	36.61	27.08	32.04	30.58
2/100	1	24.75	25.72	13.40	18.35	20.55	12.88	28.50	40.17	21.91	25.86
	2	22.00	23.69	18.74	19.19	20.90	20.54	28.39	27.44	14.26	22.03
	3	23.40	25.47	24.74	24.26	24.47	23.41	19.45	18.08	29.29	22.53
1/100	1	16.81	17.64	20.61	17.48	25.45	14.86	20.50	15.33	16.95	22.53
	2	23.21	21.55	19.65	21.76	21.54	19.09	22.87	13.00	20.14	18.77
	3	18.08	22.60	14.11	21.83	19.15	34.14	20.28	19.15	25.11	24.64
2/50	1	17.82	20.33	18.51	18.00	18.66	25.20	21.49	19.25	16.69	20.66
	2	15.95	20.51	20.92	20.69	19.37	27.38	25.00	23.58	31.33	26.82
	3	18.78	21.71	22.91	28.15	22.91	20.40	24.65	22.68	25.46	23.30
2/100, 3 in.	1	24.20	36.46	21.07	24.42	26.54	22.19	23.55	18.83	24.71	22.32
	2	18.95	19.95	32.32	15.93	21.79	29.34	27.35	37.77	20.08	28.63
	3	33.82	36.54	27.90	22.34	30.15	24.52	33.44	23.86	28.71	27.66

TABLE 32 (Continued)

Fertility treatment[a]	Plant population[b]	Phosphorus content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	13.57	19.10	16.11	22.36	17.78	24.03	17.66	21.40	24.21	21.82
	2	14.89	17.25	14.62	16.56	15.83	14.87	17.55	30.88	18.28	30.29
	3	19.52	18.02	14.59	21.54	18.42	18.70	17.53	17.57	26.30	20.07
1/100, 3 in.	1	27.51	20.34	24.83	18.48	20.29	21.06	15.14	23.18	27.72	21.77
	2	18.52	21.77	22.80	22.96	21.51	29.40	18.95	32.59	22.80	25.93
	3	28.98	20.15	13.70	19.65	20.62	22.16	14.91	13.75	15.99	16.70
0.5/50	1	15.12	18.00	14.08	14.90	15.52	16.68	9.29	12.24	10.57	12.19
	2	11.89	12.10	19.98	10.12	13.52	17.82	15.20	33.12	16.56	20.67
	3	15.66	11.87	15.81	10.10	15.61	13.33	22.14	12.63	13.33	15.36
2/25	1	21.95	23.15	18.43	18.00	20.38	27.41	24.97	17.11	28.56	24.51
	2	19.17	25.32	19.13	16.74	20.09	35.14	35.43	19.56	37.17	31.82
	3	19.87	32.41	26.20	24.44	25.73	29.22	32.30	19.83	19.59	25.21
1/25	1	17.17	13.00	16.15	14.82	15.28	15.79	15.24	14.25	29.26	18.63
	2	16.33	15.13	17.91	11.41	15.19	18.96	18.49	23.53	29.19	22.54
	3	16.50	16.74	19.13	17.80	17.54	14.92	18.57	17.30	17.00	16.95
0.5/25	1	11.83	12.95	10.41	11.47	11.66	14.36	16.45	10.96	14.68	14.11
	2	14.66	10.33	15.52	15.55	14.01	21.75	13.81	11.14	17.17	15.96
	3	10.29	15.77	14.47	18.61	14.78	24.11	13.69	14.37	14.81	16.74

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant population rates were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 33

Potassium content of corn ear in relation to hybrid, fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Potassium content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	9.40	2.80	21.82	11.52	11.40	1.91	0.61	13.28	8.36	6.03
	2	27.57	.53	3.82	5.95	9.47	7.78	2.32	15.80	26.01	12.98
	3	10.51	.02	3.20	0.39	3.53	2.01	1.45	1.10	10.68	3.81
4/100	1	39.91	41.30	41.87	29.69	38.19	29.45	12.48	26.56	20.00	22.12
	2	44.59	37.87	38.97	40.77	40.55	31.97	13.77	26.36	13.28	21.34
	3	23.16	18.66	45.35	38.06	31.31	29.78	21.15	23.39	29.43	25.94
2/100	1	50.27	48.84	33.68	46.18	44.74	20.88	22.64	26.62	18.34	22.12
	2	57.30	41.92	41.55	49.45	47.55	24.01	26.60	31.04	20.03	25.42
	3	53.74	32.62	58.37	35.33	45.01	14.67	10.73	27.38	27.10	19.97
1/100	1	34.04	50.09	42.91	36.26	40.82	30.76	25.16	19.33	16.49	22.93
	2	46.89	45.17	50.65	55.26	49.49	18.99	26.32	12.40	21.25	19.74
	3	36.38	39.59	35.49	49.50	40.24	32.47	12.02	13.86	19.92	19.57
2/50	1	38.33	47.91	47.05	40.32	43.40	23.87	18.02	21.16	20.14	20.80
	2	40.97	37.24	59.53	39.61	46.84	29.03	18.21	29.94	24.16	25.34
	3	37.62	32.97	50.36	38.19	39.78	20.78	27.05	33.51	21.69	25.76
2/100, 3 in.	1	37.96	43.16	37.99	34.74	38.46	16.75	16.17	17.51	18.61	17.26
	2	30.64	23.60	35.99	38.97	32.30	18.96	16.74	36.42	13.92	21.51
	3	43.76	38.80	39.87	33.76	39.05	17.54	19.82	22.84	7.89	17.02

TABLE 33 (Continued)

Fertility treatment[a]	Plant population[b]	Potassium content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	35.04	37.74	37.05	40.84	37.67	28.32	17.35	24.11	26.77	24.14
	2	38.53	46.00	40.29	43.68	42.10	21.86	20.96	37.25	22.50	25.64
	3	46.60	32.79	36.63	36.41	38.11	16.41	13.70	18.00	12.80	15.48
1/100, 3 in.	1	43.84	30.39	26.54	26.25	3.175	19.97	10.20	19.48	24.74	18.60
	2	30.84	15.55	40.49	24.09	27.74	22.13	15.69	27.48	22.09	21.85
	3	23.05	18.34	25.82	30.31	24.38	2.069	12.22	11.09	17.15	15.29
0.5/50	1	30.20	24.01	33.66	24.64	28.13	18.92	7.60	13.14	16.45	14.03
	2	25.91	28.20	36.74	25.11	29.99	17.29	15.54	42.03	19.99	23.71
	3	36.16	23.86	45.26	38.20	35.87	8.65	13.82	16.16	12.61	12.81
2/25	1	55.97	50.90	32.58	47.32	46.69	23.47	26.66	21.98	32.14	26.06
	2	44.12	36.28	47.92	36.74	41.26	22.83	22.77	25.95	28.09	27.41
	3	33.72	21.70	51.10	47.07	40.89	35.51	16.89	21.48	15.85	22.43
1/25	1	35.69	32.69	37.39	35.97	35.43	17.00	20.08	16.31	26.84	20.06
	2	28.75	36.44	46.30	32.00	35.87	25.21	14.66	27.73	33.65	25.31
	3	36.36	30.26	40.43	40.64	36.92	14.10	13.13	21.27	19.65	17.04
0.5/25	1	24.29	33.91	26.80	32.62	29.40	13.27	16.25	16.11	17.76	15.85
	2	32.35	25.49	34.22	28.54	20.15	20.59	10.09	11.59	13.53	13.95
	3	19.13	32.74	33.54	22.02	26.86	13.14	13.61	8.94	13.10	12.20

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation 6 inches except where indicated.

[b] The plant population rates were 19,360, 27,922 and 38,720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 34

Potassium content of corn forage in relation to hybrid, fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Potassium content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	11.43	29.28	16.76	20.62	19.45	7.00	6.82	26.35	43.03	20.80
	2	29.76	13.49	12.52	15.33	17.77	29.55	9.55	57.08	71.40	41.99
	3	21.24	6.08	10.71	17.50	13.88	14.29	10.83	16.65	30.80	18.14
4/100	1	110.88	91.36	104.25	106.85	103.33	162.83	88.26	200.20	212.43	165.93
	2	83.90	175.48	155.66	127.16	135.55	306.87	158.45	169.22	174.81	177.34
	3	128.96	130.19	92.17	175.14	131.61	204.29	180.58	211.31	215.05	202.81
2/100	1	70.18	56.65	71.80	70.57	57.30	98.74	103.03	147.48	70.90	105.94
	2	72.54	73.29	99.36	85.48	82.67	147.89	145.55	109.09	103.26	123.95
	3	131.79	69.80	91.04	61.35	88.49	153.10	109.94	141.05	168.09	143.04
1/100	1	56.65	50.95	65.55	52.85	56.50	96.39	59.04	70.38	72.93	74.68
	2	53.33	55.68	76.80	57.85	60.91	69.64	95.82	46.29	65.09	69.21
	3	66.52	51.62	52.23	65.72	59.02	103.39	85.96	72.12	79.70	80.29
2/50	1	79.81	66.89	81.00	52.90	70.15	88.68	87.23	118.40	157.29	112.90
	2	50.17	43.76	84.67	66.60	61.30	148.30	115.66	126.70	163.29	138.49
	3	79.42	80.99	81.27	80.08	111.19	129.68	111.61	141.31	141.13	123.40
2/100, 3 in.	1	91.40	70.15	80.46	66.77	77.19	140.65	145.95	142.99	82.25	127.96
	2	103.22	67.87	84.52	109.99	89.65	109.72	90.95	171.77	59.52	107.99
	3	92.83	93.93	100.79	102.82	97.59	135.58	116.99	185.47	92.36	132.60

TABLE 34 (Continued)

Fertility treatment[a]	Plant population[b]	Potassium content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	60.82	42.85	79.80	30.99	53.61	60.56	62.73	84.76	112.00	80.01
	2	47.14	65.14	57.71	56.03	56.50	70.27	75.56	85.48	86.26	79.39
	3	72.66	51.78	37.16	48.75	52.59	104.46	50.65	87.31	86.30	82.18
1/100, 3 in.	1	82.75	46.64	54.17	23.36	51.65	64.99	41.93	58.96	110.69	69.14
	2	28.50	55.30	65.76	44.53	48.52	102.23	76.93	68.37	88.09	83.90
	3	81.49	51.83	46.77	62.16	60.81	84.19	47.16	48.71	142.73	80.90
0.5/50	1	31.35	27.47	33.84	34.99	31.91	42.34	25.86	53.07	56.53	44.45
	2	35.68	26.13	37.53	18.26	29.15	44.39	47.91	122.57	74.01	72.22
	3	45.74	27.64	46.08	45.11	41.14	53.22	77.80	57.04	51.40	59.86
2/25	1	94.86	91.53	67.03	87.73	85.29	134.42	143.06	99.18	125.92	125.64
	2	28.41	97.89	58.05	64.15	75.62	124.59	172.15	117.84	117.55	133.03
	3	89.74	92.80	99.37	91.89	93.45	127.46	132.15	106.35	137.54	125.87
1/25	1	54.69	53.74	43.26	45.57	49.31	59.14	83.58	88.76	64.70	73.79
	2	51.81	43.72	50.48	57.80	49.45	79.81	73.93	97.50	92.83	86.02
	3	56.53	33.94	64.73	45.03	50.06	73.25	56.18	41.19	72.25	60.72
0.5/25	1	31.16	43.08	31.85	52.20	39.57	54.17	38.86	43.66	55.77	48.11
	2	63.51	23.17	35.47	36.46	39.65	68.66	47.59	42.92	57.91	54.27
	3	28.90	53.94	43.43	55.72	42.77	63.65	65.08	54.32	41.33	56.09

[a] Rate in thousands of pounds per acre and per cent of area fertilized (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant population rates were 19,360, 27.922 and 38.720 plants per acre for numbers 1, 2 and 3, respectively.

TABLE 35

Potassium content of the total corn plant in relation to hybrid, fertilizer rate and placement and plant population on Leon fine sand, 1963.

Fertility treatment[a]	Plant population[b]	Potassium content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
Check	1	20.83	31.67	38.59	32.20	30.85	8.91	7.43	39.61	51.39	26.84
	2	57.33	14.02	16.34	21.28	27.24	37.34	12.27	72.89	97.41	54.98
	3	31.75	6.33	13.92	17.90	17.47	16.34	12.28	17.76	41.48	21.95
4/100	1	150.79	132.66	146.12	136.54	142.53	192.27	100.73	230.76	232.43	189.05
	2	128.49	313.36	194.62	167.93	176.10	238.84	172.22	194.49	188.49	198.68
	3	152.12	148.85	137.52	213.20	162.92	234.07	201.73	234.70	244.49	288.75
2/100	1	120146	105.50	105.48	116.75	112.05	119.62	125.68	174.10	89.24	127.16
	2	129.84	115.21	140.91	134.93	130.22	161.90	172.15	140.13	123.29	149.37
	3	185.54	102.42	149.41	86.68	133.51	167.77	120.67	168.43	195.20	163.02
1/100	1	90.68	101.04	108.46	89.12	97.32	127.16	84.19	89.72	89.42	97.62
	2	100.23	100.86	127.45	113.12	110.41	88.63	122.14	58.69	86.33	88.95
	3	102.90	91.21	87.73	115.22	99.26	135.87	97.99	85.99	79.62	99.87
2/50	1	118.15	114.79	128.04	93.22	113.55	112.55	105.25	139.56	177.44	133.70
	2	91.14	81.00	144.20	116.22	108.14	177.33	133.88	156.64	187.45	163.82
	3	117.04	113.95	131.63	116.80	119.85	131.96	156.73	145.12	162.83	149.16
2/100, 3 in.	1	129.36	113.31	118.45	101.51	115.66	157.41	162.12	160.50	100.87	145.22
	2	133.86	91.47	120.52	141.95	121.95	128.68	107.70	208.18	73.45	129.50
	3	137.58	132.73	140.66	136.58	136.54	153.13	136.81	208.31	100.25	149.62

TABLE 35 (Continued)

Fertility treatment[a]	Plant population[b]	Potassium content, lbs./acre									
		DeKalb 805					Florida 200				
		I	II	III	IV	Average	I	II	III	IV	Average
1/50	1	95.86	80.58	116.85	71.83	91.28	88.89	80.09	108.87	138.77	104.15
	2	85.71	111.15	98.00	99.71	98.61	92.14	96.52	122.73	108.76	105.04
	3	119.26	84.57	73.59	90.69	85.16	120.88	64.35	105.30	100.10	97.66
1/100, 3 in.	1	126.59	76.82	80.72	49.51	83.41	84.96	52.14	78.44	135.43	87.74
	2	59.35	70.85	106.25	68.62	76.27	124.36	92.63	95.45	110.18	105.76
	3	104.54	70.17	72.59	93.47	85.19	104.88	59.38	59.80	159.88	95.98
0.5/50	1	61.55	51.49	67.50	59.63	60.04	61.26	33.47	66.21	72.99	58.48
	2	61.59	53.33	74.27	43.47	58.14	61.68	63.46	164.60	94.00	95.93
	3	81.91	51.50	91.34	83.32	77.02	61.87	91.62	73.17	64.03	72.67
2/25	1	150.83	143.43	99.61	135.06	131.98	157.89	169.72	121.16	158.06	151.71
	2	126.54	134.71	105.98	100.89	116.89	147.42	194.92	143.79	155.64	160.44
	3	123.46	124.51	150.48	138.96	134.35	162.98	154.43	153.64	122.20	148.31
1/25	1	90.38	86.43	80.65	81.54	84.75	76.14	102.66	105.05	91.53	93.85
	2	80.57	80.16	96.79	83.80	85.33	105.02	88.59	125.23	126.48	111.33
	3	92.88	64.20	105.16	85.68	86.98	87.25	69.31	62.45	91.90	77.75
0.5/25	1	55.45	76.98	58.66	84.81	68.97	67.44	55.11	59.77	73.54	63.96
	2	95.87	48.66	69.69	65.00	69.80	89.25	57.68	54.51	71.43	68.22
	3	47.13	76.79	76.98	77.75	69.64	86.79	78.79	63.26	54.43	68.29

[a] Rate in thousands of pounds per acre and per cent of area fertilizer (see Table 1). Depth of incorporation was 6 inches except where indicated.

[b] The plant population rates were 19,360, 27.922 and 38.720 plants per acre for numbers 1, 2 and 3, respectively.

BIOGRAPHICAL SKETCH

Manouchehr Maftoun was born in Shiraz, Iran, January 1, 1936. After graduation from high school, he entered the College of Agriculture, Pahlavi University in 1955, where he received the degree of Bachelor of Science in general agriculture in 1958.

In 1959, he was awarded a scholarship by the Iranian Department of Education to pursue his study in the United States. He entered the University of Florida in September 1959, in the Department of Fruit Crops and received the Bachelor of Science (Honors) in June 1960 and the Master of Agriculture in February 1962. He later transferred to the Department of Soils and is now a candidate for the degree of Doctor of Philosophy.

He is a member of the agricultural honorary fraternity, Alpha Zeta and the American Society of Agronomy.

This dissertation was prepared under the direction of the Chairman of the candidate's Supervisory Committee and has been approved by all members of the Committee. It was submitted to the Dean of the College of Agriculture and to the Graduate Council and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

April 24, 1965

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